FLIGHT and The AIRCRAFT ENGINEER

FIRST AERONAUTICAL WEEKLY IN THE WORLD : FOUNDED 1909

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Telegrams: Truditur, Sedist, London. Telephone: Waterloo 3333 (35 lines).

8-10, CORPORATION ST., COVENTRY. Telegrams: Autocar, Coventry. Telephone: Coventry 5210.
GUILDHALL BUILDINGS, NAVIGATION ST., BIRMINGHAM, 2. Telegrams: Autopress, Birmingham. Telephone: Midland 2971 (5 lines).
260, DEANSGATE, MANCHESTER, 3. Telegrams: Iliffe, Manchester. Telephone: Blackfriars 4412.
26B, RENFIELD ST., GLASGOW, C.2. Telegrams: Iliffe, Glasgow. Telephone: Central 4857.

SUBSCRIPTION RATES: Home and Abroad: Year, £3 1 0. 6 months, £1 10 6. 3 months, 15s. 3d.
Registered at the G.P.O. as a Newspaper.

No. 1709. Vol. XL. SEPTEMBER 25th, 1941. Thursdays, One Shilling.

The Outlook

Cairo Bombed

TOWARDS the end of April last the British Government issued a warning to the Axis Powers that if they bombed either Athens or Cairo, cities full of invaluable monuments of history and art, the Royal Air Force would retaliate by bombing Rome, at its own convenience, and would continue to do so until the end of the war. Since then Athens has fallen into the hands of the enemy and is therefore safe from bombing—though an extraordinary and scarcely credible rumour has reached Istambul that the Italians intend to erect on the Acropolis a monument dedicated to "Italian Victory." Cairo, however, was bombed a few days ago. It may be surmised that the orders for such a step did not originate with the Italians, for Mussolini, with all his faults, has a great respect for all that is comprised in the term archæology. But the Germans are now in command of Italy and of all operations in the Mediterranean, and the modern Huns have no respect at all for art or anything else outside the scope of their war machine. Judging by their actions in the past two years they would not mind at all if the treasures of the Cairo museum, for example, were pulverised—nor would it greatly distress them if the result were to be the obliteration of the many ancient buildings of Rome, such as the Colosseum and the Arch of Titus.

Egypt is still not a belligerent, and its Government has protested to Berlin and Rome about the bombing of Cairo. Everybody may form his own opinion as to what effect that will have on the Senior Partner of the Axis. But the British undertaking stands.

We quote the relevant passage from the Government's announcement on April 18th: "In view of the German threat to bomb Athens and Cairo, His Majesty's Government wish it to be understood that if either of these two cities is molested they will commence a systematic bombing of Rome. Once this has begun, it will continue as convenient to the end of the war. The greatest care will be taken not to bomb the Vatican City, and the strictest orders to that effect have been issued."

Spreading the Web

EVEN without counting her conquests, Germany is a very large country. When Hitler began to organise the country for war he naturally spread his munition factories as widely as possible about the country, but he could not dissipate the Ruhr. That area, together with certain ports such as Bremen and Hamburg, must remain the most convenient targets for the Bomber Command of the R.A.F., and naturally receive most attention. Flying farther afield necessarily means taking on board more petrol and therefore a smaller weight of bombs. Our bombers can reach places in Italy and Poland, but nearer targets give a better return for the effort expended. So it has happened that quite a number of places in Germany have not received any visits from British night bombers, or only a few. Among them we may mention the Dornier factory at Friedrichshafen and the original Messerschmitt works at Augsburg, and there are many others. Most of the flying training schools have been established in Eastern Germany, and, of course, it would be very profitable to interfere with their work. Such enterprises depend on the numbers of the heaviest bombers which are available, and that

number has now begun to increase in a way which must surely seem ominous to the German people.

Now that the nights are getting longer we may expect to hear of more raids on distant targets in Germany. There is another unpleasant prospect for the Germans in the winter. The intensity of the fighting on the ground in Russia must diminish as the winter sets in. While the land battles have been in progress the Russian bombers have rightly devoted their energies in the main to hammering the German armies. When they have more leisure in the winter it may be confidently expected that they will devote more attention to bombing targets in Germany by night, and they will naturally deal with Eastern Germany. The comparative immunity which that part of the country has so far enjoyed is not likely to last for long.

Talk About Torque

OUR correspondent "Mystified" certainly seems to have put a cat among the pigeons when he questioned if contra-rotating airscrews really do eliminate torque-reaction. Letters on the subject have poured in almost daily, and a goodly selection is published this week.

In recent years no such apparently innocent remark has caused such a flood of letters. Even Dr. Lanchester's definition of efficiency in connection with reaction-propulsion, which gave rise to some heated arguments, did not cause such widespread interest.

When flying was still "in its infancy," someone propounded the question: suppose an aeroplane were flying at 60 m.p.h. airspeed against a head wind of 60 m.p.h., and the engine stopped at exactly the instant when the wind dropped, what would the aeroplane do? Strangely enough, that simple but unlikely hypothetical question had much the same effect on our post bag.

That opinions are divided is obvious from a perusal of the letters. Even such authorities as Dr. Henry Watts, who has been designing airscrews since about 1911, and Mr. Granville Bradshaw, who designed the A.B.C. aero engines during the last war, seem to be in opposite camps on this vexed question.

With such weighty advocates in the field, we feel a natural hesitancy in acting as judges and final arbitrators. Dr. Watts suggests, and we heartily endorse the suggestion, that those who claim the torque-reaction *is* eliminated should provide the proof. In the meantime it does seem to us that the torque reaction which causes the aircraft as a whole to drop one wing must be eliminated if the two halves of the contra-rotating airscrew are absorbing equal power. But equally we can agree that within the aircraft itself there must be torque reactions which have to be resisted by the structure, but which have no effect on the attitude of the machine. After all, one cannot bank an aeroplane by sitting in a seat and pressing down with one hand and lifting with the other.

SPITZBERGEN BLITZ : An air view of the burning of the 150,000-ton coal dump to prevent the Germans using it. The lower wing-tip and float of the Supermarine Walrus from which it was taken appears on the right of the photograph. It is probable that the Walrus was catapulted from one of the attacking warships.

War in the Air

The Mediterranean Convoys : Threat to Kiev : Bombing Messina

THE R.A.F. Wing in Russia is, as was stated in our last issue, a self-contained unit acting under the general command of the Red Air Force. The Wing has been in contact with the enemy. The fighter aircraft which the Prime Minister said are being sent to Russia in hundreds are being handed over to the Red Air Force and will be flown by Russian pilots. No doubt we are sending with them supplies of the high octane fuel which is used in our engines, as well as spares, and most probably instructors to teach the Russian pilots how to handle the machines, and aircraftmen to maintain them.

The bombing of Cairo by Axis aircraft in the early hours of September 16th has been followed by a protest to Berlin and Rome by the Egyptian Government, which is not a belligerent.

News from Russia continues to be the reverse of circumstantial, but the threat to Kiev, the capital of the Ukraine, appears to be growing more serious, and the Italians claim that mass air attacks have been made on the fortifications outside the city. The Germans have been dropping leaflets on Leningrad threatening to burn the place if the inhabitants do not surrender. The said inhabitants are reported to be full of the most resolute spirit.

Whatever the results of the present great battles in Russia, the approach of winter must soon slow down the fighting in that country. Winter, however, is the best campaigning season in North Africa, and the Axis is evidently massing troops and supplies at Tripoli and Benghazi, no doubt in preparation for another attempt to force open the way to Egypt and the Suez Canal. Probably the bulk of the troops are Italian, but the direction of affairs is certainly in German hands, and the attack is likely to be much more energetic than that which was attempted in a half-hearted way by Marshal Graziani last year. For this reason the constant attacks made on enemy convoys between Sicily and the African ports by British submarines and by the R.A.F. and Fleet Air Arm are of the greatest importance. The number of enemy ships sunk and damaged while in transit, and also in the harbours after arrival, has been most encouraging. But despite all our efforts it is clear that many ships are getting through and doubtless unloading their cargoes and troops. Against this we may reflect that, despite losses in Greece and Crete, General Auchinleck and Air Marshal Tedder have more troops and more aircraft at their disposal than General Wavell and Air Chief Marshal Longmore could boast last year. Moreover, the campaigns in

FOR DAVY JONES'S LOCKER : A German flak ship being attacked by Blenheims of the Bomber Command. The splashes are from bombs dropped by the Blenheim which took the photograph—its tail wheel appears in the top right-hand corner.

PLANTED IN THE PLANTATION : This Wellington was shot up by an Me 109 and gave up the ghost only five miles from its home base owing to fuel shortage.

WAR IN THE AIR

East Africa are now over, and the shores of the Red Sea and Indian Ocean are in our hands, so that supplies can reach the Middle East that way without much risk. With the developments of communications in Persia (the real name of the country is Iran, but Mr. Churchill likes to call it Persia, so let us follow his lead, although that name only refers properly to the province of Fars) supplies for Russia may also go in from the south-east. The enemy has made several attempts to block the Suez Canal, and it ought not to be impossible to do it, for we have more than once blocked the Kiel Canal and the Corinth Canal, but blocks can be cleared, and in any case the Middle East is not entirely dependent on carriage by water up from Suez.

African Nights

THERE are night-fighters in the Middle East, and they shot down one of the enemy bombers south-east of Suez not long ago, while on the same night another of our fighters shot down a Savoia bomber in the western desert. A sergeant major who was sleeping in a tent not more than thirty yards from the spot where the bomber crashed had a narrow escape. "After the bombs and petrol had exploded pieces of the wreck fell down about us," he said. "But it was worth it. We had ringside seats."

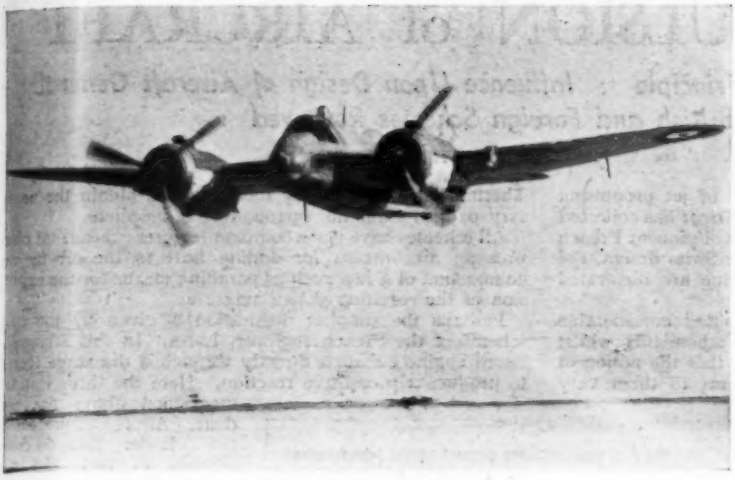
Messina, the port in Sicily nearest to the Italian mainland, was visited not long ago by R.A.F. heavy bombers. The targets were the power house and the landing stages of ferries connecting Sicily with the mainland. Numerous heavy bombs were dropped. Some pilots dived to low altitudes to straddle their objectives. One of the first wave of aircraft started a fire near some oil tanks which was developing healthily when the aircraft turned home. One Scottish pilot from Dumfries said: "I had hoped to see Etna erupting, as I have never flown near it before, but there wasn't a glow from it. However, what we did see was much better than a volcano. When we went in light *flak* was being hosepiped indiscriminately all over the place, some from warships in the harbour. Then heavy A.A. guns on the mainland started. We dropped sticks of bombs right across the target, but couldn't see the explosions against the vivid light from a fire that started raging near the Citadel. It was a 'corker,' and I was so fascinated by it that I 'stooged around' watching it for about half an hour. When we turned homewards it was still spreading. We saw it shining in the sky behind us until Etna hid it."

H.M.S. IRREPRESSIBLE? A Fairey Swordfish receives the "O.K. for height" signal when landing on H.M.S. *Ark Royal*. From the fact that all its bombs are still in their racks the Swordfish appears to have been on a fruitless journey.

MINISTER FOR THE INTERIOR: An operative polishes the inside of a 500 lb. bomb casing in a Canadian factory. When it has been filled it will be delivered to the R.A.F. who will "deliver" it to the Germans.

A Great Day's Work

R.A.F. raids on Germany continue to increase in intensity by day as well as night. Hamburg has now been raided over 75 times. Of late, Karlsruhe has been a favourite target. As for the day raids, one on September 17th may be singled out for special notice, though there have been many others. On that day there were at one time more than 300 British fighters over enemy-occupied territory. They went as escort and vanguard to bombers attacking a power plant in Northern France. They protected the bombers from fighter intervention and saw them hit their targets. In the course of the day's operations many more British fighter aircraft went over France. Seven Me 109s were destroyed and a number of others probably destroyed. Representatives of all the countries which have provided pilots for Fighter Command took part in the operations. A Polish Flight Lieutenant shot down two enemy aircraft. A Canadian squadron destroyed another while protecting a launch of the air-sea rescue service which was trying to locate a British pilot who had been seen to bale out over the Channel. A new Spitfire squadron, named after a famous Indian State, which shot down two



MIDDLE EAST AIR POWER : Bristol Beaufighters, armed with four 20 mm. shell-guns and a further six machine guns, are in service in quantity in the Western Desert. In one attack alone 36 Italian machines were destroyed on the ground.

enemy aircraft while still in training last month, took part in these offensive sweeps. It destroyed two Mes. The Polish pilot of another squadron was credited with the destruction of one German fighter after he had been seen to collide with it in mid-air over Northern France. The wings of the Spitfire were torn off and the Me 109 burst into flames. A Scottish Wing Commander with the D.F.C. and bar got one. A Free Frenchman under his command got another.

Later News

THE news that the Germans have occupied Kiev is not cheerful, but it was scarcely unexpected. The same can be said about the German claim to have reached the shore of the Sea of Azov and cut off the Crimea. But, as was said in these pages when the Germans first started to advance in Russia, the historic strategy of Russian armies is to be able to retreat and at the same time to maintain their fighting power. The Germans no doubt eagerly desired to be able to have some concrete victories to show their people before the winter set in, but at the same time they are right when they proclaim that their main object must be to destroy the Russian armies. If the latter can continue retreating with supply bases behind them, the Germans will be faced with a situation similar to that which brought about the downfall of Napoleon.

Round Leningrad the Germans do not seem to be making rapid progress, and it is reported that there the opposing air forces are more evenly matched than they are elsewhere. The city has not yet been subjected to anything like a general bombardment, either from the ground or from the air, and the Russian bombers and fighters are showing plenty of enterprise in attacking the Germans round the defences of the city.

On Saturday, September 20th, the R.A.F. Fighter Command had another very busy day; in fact, it has been officially described as its busiest day since January. They escorted bomber formations to various targets in Germany and occupied territory, and a number of attacks were made on convoys, in the course of which nine ships were hit.

The Bomber Command has made a night raid on Stettin, the largest enemy port on the Baltic, situated near the head of the estuary of the River Oder. Large fires were kindled among the docks, warehouses and railway yards. The news of this effort will doubtless bring cheer to the hard-pressed Russians.

A Spitfire recently returned to its base after having been hit by four cannon shells and machine-gun bullets as well. These were the result of an encounter with a Me 109F on an offensive sweep. After eluding it he shot up an enemy ship and damaged another Messerschmitt.

BRITISH AIR LOSSES TO SEPT. 20th.

	Over G.B. Fighters	Over G.B. Pilots	Over Continent Aircraft	Middle East Aircraft
Sept. 14	0	0	0	0
,, 15	0	0	11	7
,, 16	0	0	3	0
,, 17	0	0	15	0
,, 18	0	0	11	0
,, 19	0	0	3	0
,, 20	0	0	14	0
	0	0	57	7

Totals : Northern Area, 2752 ; about 392. Middle East,

WAR IN THE AIR

ENEMY AIR LOSSES TO SEPT. 20th.

	Over G.B.	Over Continent	Middle East
Sept. 14	0	0	14
,, 15	1	1	1
,, 16	1	7	0
,, 17	0	12	0
,, 18	0	17	0
,, 19	0	2	0
,, 20	1	15	0
	3	54	15

Totals : Northern Area, 5,366 ; over 2,123. Middle East,

RELEASE AND REND : Bombing up a Martin Maryland on the Western Desert. The bomb-aimer's conservatory must get a trifle warm under Egypt's sun.

JET PROPULSION of AIRCRAFT

PART III.—The Thermal Jet Principle : Influence Upon Design of Aircraft Generally : Further British and Foreign Schemes Reviewed

By G. GEOFFREY SMITH

THIS week, in the review of types of jet propulsion plants of various countries which *Flight* has collected over a period of years, the designs of pioneer French and British experimenters, a very recent Swiss design, the Eichelberg, and a further Whittle scheme are illustrated and described.

The two preceding articles have aroused considerable discussion and controversy. Several correspondents, whilst expressing their interest, have intimated that the notion of jet propulsion without an airscrew seems to them very futurist. Others, although intrigued, regard it as one of those "new-fangled" ideas in an entirely new field of development with little hope of success. The technical interest of the proposed schemes is undoubted, though many confess inability to follow clearly the working of the plants, since so many new principles are introduced. With this view some sympathy may be expressed, as the particulars available are, necessarily at present, incompletely detailed.

IN this, the third of four articles discussing the possibilities of the propulsion of aircraft by jet impulse reaction, that is without the aid of the conventional airscrew/engine combination, we review more British and foreign power plants. The important effect upon the design of aircraft generally were jet propulsion to be proved to be efficient is also indicated.

Previous articles of this series appeared in "Flight" of August 28th and September 11th.

Previous notes have largely dwelt upon the functioning of plants when in motion, and some correspondents appear to have found it difficult to visualise a start. This is rather surprising, particularly in the case of reciprocating plants where the starting-up of one engine by any of the usual methods—electric, compressed air or cartridge—will successively bring the whole plant into operation. With the turbine plants, starting is admittedly not so obvious. Generally either an electric motor or a small auxiliary air compressor, driven by any means available, will be necessary to start the turbine rotor and to raise an initial pressure to support the combustion of fuel.

How It Works

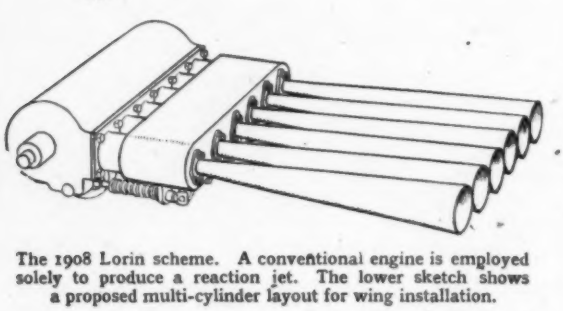
In an endeavour to make the principle readily understandable, let us reduce the "thermal jet" to its essential terms. Again it should be stressed that it must not be regarded as a "rocket" system for one very important reason: in a rocket the necessary oxygen for supporting combustion is contained in the explosive material employed. Thermal jet systems carry fuel only and obtain the necessary oxygen from the surrounding atmosphere.

All schemes have three common features: means for compressing air; means for adding heat to the air by the combustion of a fuel such as paraffin; means for the expansion of the resulting gas-air mixture.

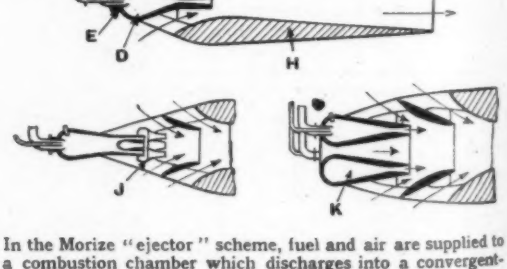
Perhaps the simplest illustration is given by the 1908 scheme of the French engineer, Lorin. In this a conventional engine exhausts directly through a discharge funnel to produce a propulsive reaction. Here the three features mentioned above are evident. Air is compressed in the cylinder, there is combustion of fuel and the effluent expands in the discharge funnel. Apart from the energy used in driving the usual auxiliaries, the engine functions solely to produce the reactive jet. No power is taken off the engine crankshaft. Lorin visualised multi-cylinder units of this type, as shown in perspective, installed in the wings of aircraft.

By modern standards this design is only of historical interest. Nevertheless it deserves an honourable mention, as it was the original suggestion to employ a reciprocating engine and use part of the combustion energy to compress the air.

It will not have escaped notice that by employing jet propulsion, whether the power plant or plants are located in the fuselage or in the wings, a number of important modifications in aircraft design become possible. The absence of an airscrew confers manifold advantages. For instance, the fuselage may be quite low, a welcome improvement as regards servicing and stowage. As the usual airscrew clearances are unnecessary, the undercarriage may be relatively low and of lighter construction. Indeed, it may be questioned if the weight and complication and cost of mechanism to enable the undercarriage to be retracted is justified under such conditions. Should the undercarriage proper be eliminated, whatever speed may be lost due to



The 1908 Lorin scheme. A conventional engine is employed solely to produce a reaction jet. The lower sketch shows a proposed multi-cylinder layout for wing installation.



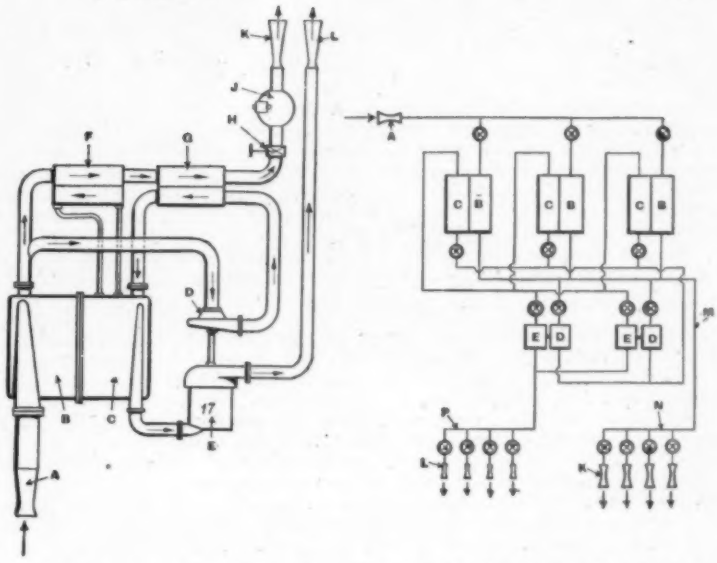
In the Morize "ejector" scheme, fuel and air are supplied to a combustion chamber which discharges into a convergent-divergent tube. Air enters the forward end of the tube by suction, joins the gas stream, and discharges at the rear.

ET PROPULSION

the drag of projecting wheels or half-wheels, a considerable saving of weight, complication and man-hours would be effected. The added reliability thus gained would be definitely on the credit side in offsetting speed losses due to the non-retractable wheels. However, only careful calculation and wind tunnel investigation could determine the relative merits of this conjecture, if and when all other problems are successfully solved.

The pilot can be seated well forward and given a wide field of view with no interference. In military aircraft the armament, whether offensive or defensive, may be more conveniently arranged and will command a less restricted field of fire.

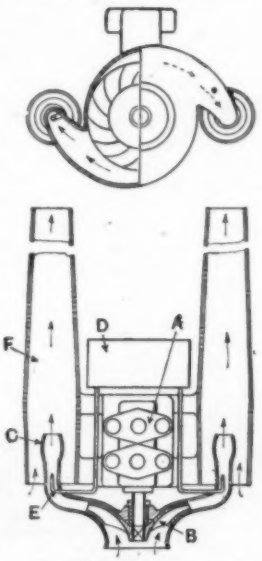
To continue details of jet propulsion designs, I take first the 1917 scheme of O. Morize, of Chateaudun, France. In this, liquid fuel is delivered to a combustion chamber, charged with air by an engine-driven compressor, and on combustion discharges through a nozzle into the intake of a convergent-divergent "ejector." A complete plant is shown diagrammatically in the illustration. An engine A drives a compressor B which delivers air through an equalising chamber C to the combustion chamber D, the walls of which are lined with refractory material. The air inlet surrounds the jet E supplied with liquid fuel from tank F by an engine-driven pump G. A suitable means of ignition, electric or incandescent, is provided and the combustion products are discharged through the combustion chamber nozzle into the convergent forward end of the "ejector" tube H. This creates a region of low pressure and air is induced into the end of the tube H to join the rapidly moving gas stream. In the divergent portion of the tube H the velocity is diminished, thus imparting increased pressure to the stream as it leaves the discharge orifice.



A Swiss design, the Eichelberg, has an independent engine-charging system driven by a separate exhaust gas turbine. Waste gas from the turbine is not mixed with the main air supply but discharged from a separate nozzle to assist propulsion. On the right is a schematic layout of a complete plant having three compressor aggregates and two engine charging units.

The stated aim is to secure a negative pressure at the forward end and a positive pressure at the rear and thus exert a propulsive thrust in a direction opposite from the discharging gas-air stream. Control of the thrust is effected by varying the quantity and pressure of the fuel and the charging air which supports combustion. Modified types of "ejectors," of which two are shown, had a series of air intakes, a plurality of combustion chamber nozzles, as at J, or an annular combustion chamber, as at K.

In the same year H. S. Harris, of Esher, devised a propulsion plant of considerable interest, although its fate remains for the time being obscure. He also sought to induce air into the discharge tube in order to increase the mass of the jet. Instead, however, of achieving this aim by allowing the combustion gases to expand in a tube of increasing cross-sectional area, he inverted the process since adopted.



The British Harris plant also uses induced air, but the combustion chambers discharge into divergent-convergent tubes.

The combustion gases enter the discharge tube at high velocity and low pressure (approximately atmospheric pressure) in the form of a cylindrical stream or jet. As this jet is cooled and contracted on its way to the discharge nozzle a "depression" is produced which induces the inflow of air at the open forward end of the discharge tube. The tube is of a considerable length in order to ensure that the stream of gas and air issuing from the discharge nozzle is completely cooled. Consequently, no rapid expansion will occur at the nozzle which might give a pressure drop and induce a reverse flow. To compensate for the continued cooling and the corresponding decrease in volume of the stream, the discharge tube is of decreasing cross-sectional area, thus maintaining the velocity.

It is somewhat remarkable that the scheme contains no suggestion of utilising the effluents of the engine which drives the blower supplying air to the combustion chambers. On the other hand, it appears ahead of its time in the proposal to employ powdered coal as a fuel, as an alternative to liquid hydrocarbons, such as petrol or paraffin.

Petrol Fuel

Petrol is used for the twin-jet plant shown in the diagram. A twin-cylinder engine A drives directly a low-pressure blower B, which draws air from a forward axial intake and delivers to combustion chambers C. Fuel from tank D is supplied to jets E and mingles with the air to form a combustible mixture which is ignited by unspecified means. Presumably an electrical ignition system would be provided. The combustion chambers are of an increasing cross-sectional area to accommodate the expansion of the charge without increase of pressure and terminate in a slightly convergent nozzle to increase the velocity of the gas stream, which issues as a cylindrical jet. Each chamber is positioned axially in a long discharge tube F open at both ends. The issuing gases, on cooling in this tube, produce a partial vacuum which draws air into the tube in the direction of flow and increases the mass of the rearwardly flowing stream.

A number of modified arrangements were suggested. Instead of two jets, a single large discharge tube with a plurality of combustion chambers may be provided. Or a series of combustion chambers may be fitted in each discharge tube and additional air be admitted at several points along the tube at successive stages. The charging blower,

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it was suggested, could be driven by means of a rotor mounted in the discharge tube; in which case, presumably, the engine would be used only for starting. Either the complete discharge tube or a terminal portion may be mounted to swivel horizontally and vertically to effect or assist the control of the aircraft. Furthermore, means of temporarily closing the discharge end of the tube may be provided to cause the gas stream to issue from the forward end of the tube to produce a braking effect when landing.

A Swiss Design

Dr. Gustav Eichelberg, of Zürich, is concerned to differentiate the respective air pressures for propulsion and for charging the motive unit driving the compressor. For efficient operation the pressure at the discharge nozzles should be about 2 atm., and as the flying altitude is increased this pressure should be reduced in approximate proportion to the fall in atmospheric pressure.

In systems in which the engine is charged from the main air supply, this involves a fall in engine output and, as a consequence, a reduction in the propulsive effort. To increase the pressure of the propulsive air is undesirable, since it results in an increased discharge velocity which seriously impairs the efficiency of the plant. On the other hand, an absolute pressure of from 4 to 5 kilograms per square centimetre (57 to 71 lb. per square inch) may be required for charging in order to keep the weight and dimensions of the engine at a minimum. In a two-stroke engine, generally accepted as the most suitable type, the exhausting pressure would be too high for efficient use as a propellant.

To enable optimum pressures to be employed for each function, the engine exhaust drives a turbine, which in turn drives a separate blower to raise a portion of the main air supply to the required charging pressure. Although the gases leave the turbine at a lowered pressure they are not passed into the main air supply, as this would give rise to losses on mixing, but instead are discharged from special nozzles to provide supplementary propulsive effort. The entire power output of the turbine is absorbed in driving the charging blower. Thus, when operating at a high altitude, the air on the delivery side of the compressor can be adjusted to the appropriate pressure, whilst the charging pressure can remain substantially constant. This is possible as the increased pressure drop (energy output) at the gas turbine offsets the higher pressure ratio (energy input) at the charging blower.

As the charging pressure is relatively high the air becomes heated by compression. It is therefore desirable to cool it after leaving the blower to avoid a loss of charge weight at the engine. To dissipate this heat to the atmosphere by means of surface coolers would complicate construction, possibly increase aerodynamic drag and also involve a loss of energy. The same considerations apply to the heat dissipation necessary for the cooling of the engine. In each case the liberated heat is turned to useful account by transferring it to the main air supply in a separate heat-exchanger of the contra-flow type. The temperature of the fluid-cooling medium is likely to be lower than that of the charging air, so it is expedient that the respective exchanges be inserted in that order.

On the left of the illustration is a diagram of a complete unit. Air enters through a diffuser intake A, which is located either to take advantage of the dynamic pressure set up by the aircraft in flight or to suck in the boundary layer from a suitable point of the fuselage or wing. The compressor B is either mechanically coupled or, as indicated, structurally combined with a two-stroke engine C. From the air leaving the compressor a supply is drawn off by the charging blower D driven by the exhaust gas turbine E. Cooling fluid from the engine cylinder jackets is circulated through heat-exchanger F, and the charging air is passed through exchanger G on its way to the engine intake manifold. After traversing the heat-exchangers, the main propulsion air passes a regulating valve H and combustion chamber J, into which supplementary fuel can be injected to furnish additional power for peak loads, to the discharge nozzle K. The waste gases from turbine E are discharged from the nozzle L.

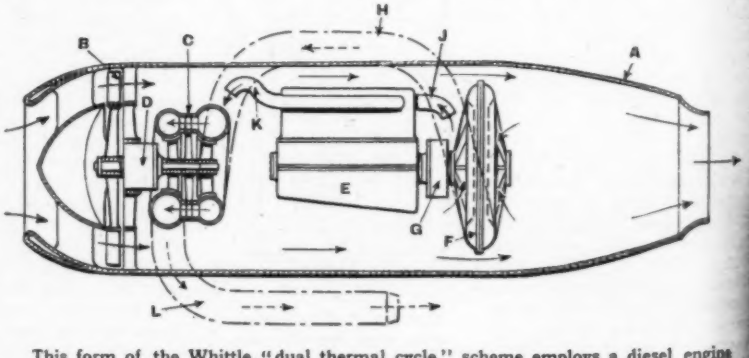
To obtain operational flexibility and reliability a complete plant would comprise a plurality of compressor aggregates, charging units and heat-exchangers, suitably interconnected to enable various combinations of components to be brought into co-operative function. An example of such a plant is given on the right of the illustration. To simplify the diagram the components are lettered to correspond with those of the single unit and heat-exchangers, and supplementary combustion chambers have been omitted.

Three compressor aggregates and two charging units are employed. Air entering intake A is distributed to the compressors B, and from these is collected in conduit M and fed to a distributing manifold N for discharge from nozzles K. Part of the compressed air is bled from conduit M for the charging blowers D and thence distributed to the three engines C. The exhaust gases are collected for the turbines E, from which the waste gases are led to a distributing manifold P for the auxiliary discharge nozzles D. Suitable regulating and controlling valves, as indicated, enable independent components to be brought into operation or shut down as desired. The number of units may be varied to suit requirements and, of course, any suitable type of engine, compressor or charging blower may be utilised.

British Anticipation

The ideas embodied in the Swiss scheme would seem to have been to a large extent anticipated by the British inventor, F. Whittle. In 1936 he outlined a "dual thermal cycle." All the working medium, air, was passed through a "lower cycle," and a portion of the medium was passed through a second "higher cycle." The lower cycle consisted of a compression of air from atmospheric to an intermediate pressure, an expansion due to withdrawal of a portion of the air for the higher cycle, and finally an expansion back to atmospheric pressure. In the higher cycle the air was compressed from the intermediate to a higher pressure, heated by the combustion of a suitable fuel and expanded back to the intermediate pressure. As in the Eichelberg scheme, the effluent from the motive unit of the higher cycle was not mixed with the main air stream but conducted to an auxiliary propulsion nozzle.

(*Continued on page 201.*)



This form of the Whittle "dual thermal cycle" scheme employs a diesel engine and compressor to supply air and combustion products as the working medium to the turbine, which drives the main compressor. The effluent from the turbine is utilised for an auxiliary propulsion jet.

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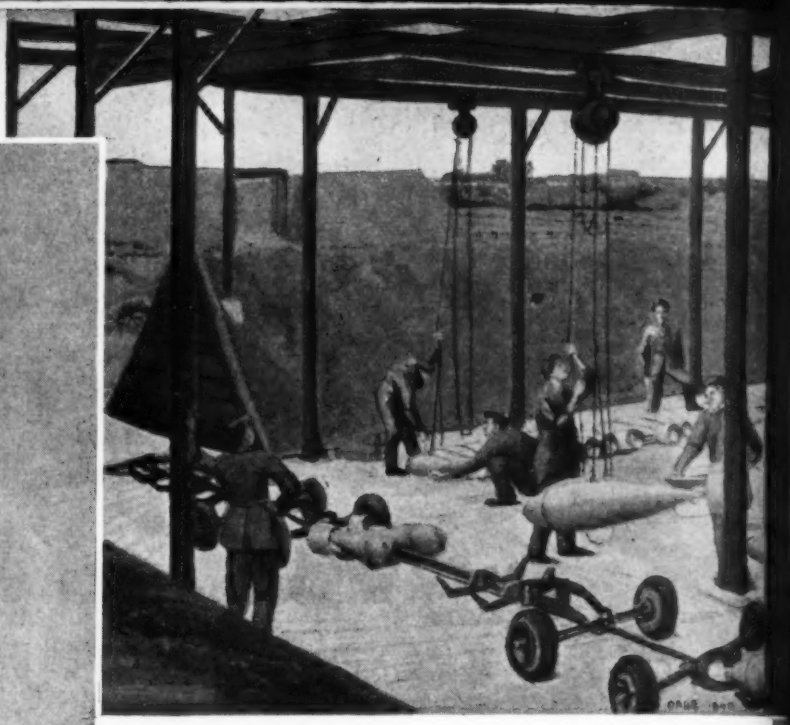


THE two portraits in the top row are (*left*) Flt. Lt. G. Allard, D.F.C., D.F.M. and Bar, of No. 85 Squadron, and (*right*) Sgt. Plt. Snowden, of No. 99 Squadron. Armourers at work in a bomb store are depicted above, and on the right is a Wellington bombing up.

In the bottom row the four portraits are—*from left to right*—Flt. Lt. P. S. Turner, D.F.C., who has since received a Bar; Sqn. Ldr. D. S. Bader, D.S.O., and Bar, D.F.C., who was promoted to the rank of Wing Commander before being captured recently. Sqn. Ldr. A. G. Malan, D.S.O., D.F.C., who received his D.S.O. for his excellent work in command of No. 74 Squadron, and Flt. Lt. Tamblyn, D.F.C., of No. 242 Squadron.

All ranks quoted are those held at the time Captain Orde made the portraits.

R.A.F. CANVAS No. 2

A Selection from Another of Our Eminent War Artists—Captain C. Orde

WE.... THE R RS

We, the designers and workers and
industry have special reason to k itain

Let us recognise, then, our respo wards
and its great work of caring for their

Let us all contribute liberally and influenc
to support the fund.

ded by

E RS OF "FLIGHT"

workers and engineers, of the aircraft
n to Britain owes to the Royal Air Force.

r responsibilities towards the R.A.F. Benevolent Fund
ng for all their dependents in need of help.

ally and influence we may have to get others

ded by The de Havilland Aircraft Co., Ltd.

W.A.A.F. MECHANICS

Girls Take Over an Ever-increasing Number of Ground Duties

TRAINEES of the W.A.A.F. are being taught service and maintenance of engines and airframes. Top (right) Starting up a Rolls-Royce Kestrel on a Hawker Fury. (Left) A class learning the mysteries of the D.H. airscrew. Centre (right) Installing a Siddeley radial engine. (Left) Rigging a Hawker Hector of pre-war vintage. (Bottom) A group of feminine flight mechanics being shown how to start and "run-up" the Perseus engines of a Blackburn Botha.

Fifth of the New Series

FRIEND or FOE?

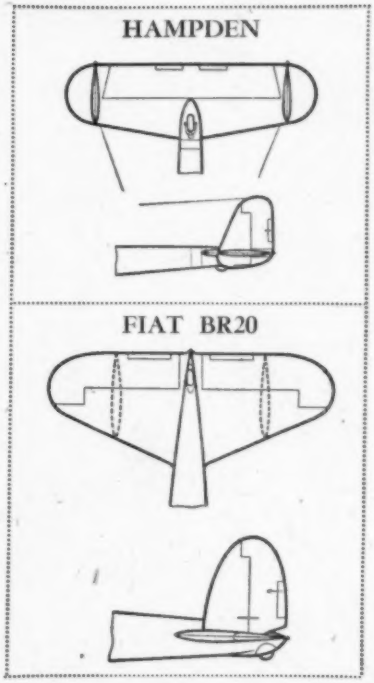
Typical British Twin Tail Compared with an Italian

HAMPDEN: Cantilever unit, fins and rudders set inboard from tailplane tips and extending below horizontal surface. Single elevator forms straight trailing-edge between rudders.

THE Fiat BR20 is one of the very few Italian bombers so far seen in the immediate vicinity of this country. It will be remembered that the German command did once persuade the Regia Aeronautica to lend a hand in the highly hazardous business of trespassing over these shores. Doubtless they expected to be able to echo that famous Roman who once said, "Veni, vidi, vici!" but, though they certainly came, it is equally certain that they did not conquer, and about all that they saw was their own machines being shot out of the sky.

It is just possible, however, that a sorely tried *Luftwaffe* may again "persuade" Mussolini to contribute to our valuable collection of scrap metal. In any case, the Fleet Air Arm gets about quite a lot, and often comes across Italian aircraft nearer their own territory, so the similarity between the three-quarter rear view of a Hampden and a BR20, *except for their tail units*, is well worth illustrating in this series. A glance at the accompanying pictures will show how far this similarity goes—the well-tapered wings, both with dihedral outboard of the radial engines, the wheels of the retracted undercarriages protruding from the nacelles, the deep bomb bays terminating near the trailing-edges and even the retractable tailwheels. These common features impart a misleading resemblance, from this particular angle, to two rival aircraft which are quite distinctive in appearance when seen from almost any other viewpoint. But, once again, "by their tails ye shall know them."

The twin-tail design of the Hampden is typically British, and follows what is probably the most frequently favoured cantilever layout for this type of empennage in this country. The fins and rudders are set inboard from the tips of the tailplane and project below the horizontal surfaces. The elevator is a single member extending across the span of the tailplane between the rudders and projecting clear of the extremity of the fuselage, and having two inset trimming tabs. The trailing-edge is quite straight, the leading-edge backswept and the tailplane tips well rounded. Fins and rudders conform to the same rather prim style, having a straight slope to the leading-edge, a straight vertical trailing edge and curved apex and base. This design may not be strikingly graceful, but it cannot be dubbed angular, and it is clean and business-like.



The tail of the BR20 would appear to suffer from compromise, for it has the type of tailplane which one associates with a single fin and rudder; it bisects the rear extremity of the fuselage with elevators on either side. The semi-oval fins and rudders do not, in this case, extend below the horizontal surfaces; they sit on top of them and are set appreciably farther inboard from the tips. Furthermore, the fins are braced by double struts, a feature which accentuates the impression of compromise. The whole unit, in fact, suggests that its designer began with a single-tail layout, but later chopped off the single fin and rudder and tacked on the twin vertical members to the existing tailplane—a "trial-and-error" method by no means unknown in the evolution of tail units whose aerodynamical peculiarities are a notorious source of headaches to airframe designers.

(Next week: Westland Lysander and Henschel Hs 126.)

FIAT BR 20. Double strut-braced twin fins and rudders on top of tailplane which bisects extremity of fuselage. Elevators on either side as in single-tail designs. Tailplane similar in plan to Hampden but with more backsweep to leading-edge.

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FIGHTER PHILOSOPHY

Russian and American Opinions on Design of Fighters

SOME Russian ideas on fighter design are expressed in M. Stroyeu's article, of which the following is an abstract:—

The science of tactics depends on the quality of men and machines. Technical development is never static, and at any moment has possibilities of progress. It is the business of tactical science to examine these possibilities and incorporate their fulfilment in the design of new weapons, in the present case, fighter aircraft.

The first essential for formulating the tactical requirements of fighters is an exact and concise definition of the duties to be performed.

The current definition of these duties is: *the destruction of the enemy's air forces, in the air or on the ground.* This, however, is insufficiently precise, and compliance with the requirement may lead in the direction of the "all-purpose" machine which is such a common and undesirable feature of peacetime design development. Actually, the two requirements of aerial combat and ground attack are contradictory in their demands on armament and performance, and their combination results in a compromise type inadequate for either purpose.

Aerial combat should remain the paramount duty of the fighter aircraft.

Destruction of enemy aircraft on the ground can be performed equally well, or better, by bombers or "attack bombers." Furthermore, aerial combat still remains the most powerful and effective means of securing mastery in the air.

Apparently contradictory, successful German practice in the present war does not, however, refute this contention. The Poles were unready, and in the case of France, undoubtedly treachery and defeatism played a part. When faced by a resolute adversary, willing to fight aggressively, the Germans adopted just the method of aerial combat which is now recommended, as is shown by the Battle of Britain. Having failed to shake the morale of the R.A.F. in aerial combat, despite the great disparity in numbers, the Germans were obliged, if only temporarily, to abandon plans of further aggression, and revert to orthodox methods of night and day bombing.

THE FIGHTER COMMAND of the Royal Air Force has been conspicuously successful in accomplishing the tasks which have fallen to its lot in the first two years of the war. The quality of the men, machines and organisation which compose it has been shown to be of a high order; higher, we think, than that of any other fighter force in the world. But nothing stands still and, in addition to trying out our new ideas, it is always instructive to discover what other people are thinking. We publish in this article Russian and American opinions on fighter design, the former having been written by M. P. Stroyeu and published in the Russian journal "Aeronautical Engineering." The translation is published by courtesy of R.T.P. of the Ministry of Aircraft Production. The second part of our article is written by Lawrence D. Bell and was originally published in "Aviation." Mr. Bell is president and general manager of the Bell Aircraft Corporation, designers and manufacturers of that revolutionary single-seater fighter, the Bell Airacobra.

It aerial combat is to be the predominant rôle of fighter aircraft, all features of design should be directed to this end, leaving such things as bomb loads and reconnaissance equipment in a subordinate position. This leaves the following fighter types to be considered:—

A. Ordinary single-seater fighters:
- (*a*) Manœuvrable:
  1. Biplanes and sesquiplanes;
  2. Monoplanes;
- (*b*) High speed:
  3. Monoplanes of usual type (tractor airscrew, engine in front).

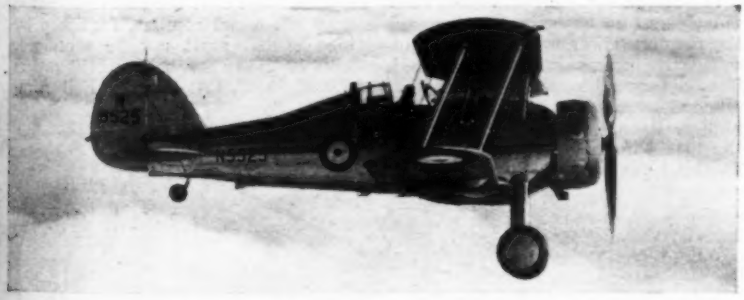
B. New types of single-seater fighters:
4. Tractor airscrew, engine behind;
5. Pusher airscrew single-seaters;
6. Tandem twin-engined single-seaters;
7. Ditto with separated engines.

C. Two- and three-seaters:
8. Single-engined two-seaters;
9. Twin-engined dual-purpose aircraft;
10. Twin-engined exclusively fighter aircraft.

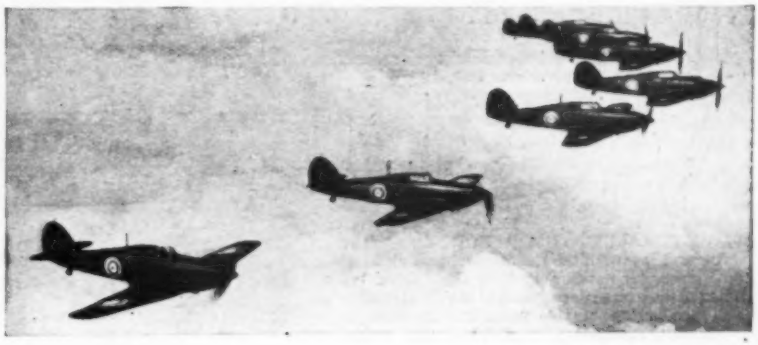
D. Multi-seaters:
11. Multi-purpose aircraft; and also
12. Night fighters;
13. High-altitude fighters.

Dealing with the differentiation between "manœuvrable" and "high-speed" fighters, it must be said that there is absolutely no reason to give preference to one or the other. Manœuvrability, leaving aside for the moment considerations of relative control surfaces and aerodynamic qualities, is principally a function of the wing-loading in relation to stability at low speeds, the manœuvrability of an aircraft in the horizontal plane being limited by the physiological effects on the pilot. The most manœuvrable aircraft will therefore be that with the lowest wing loading and the lowest flying speed.

The tendency to increase wing



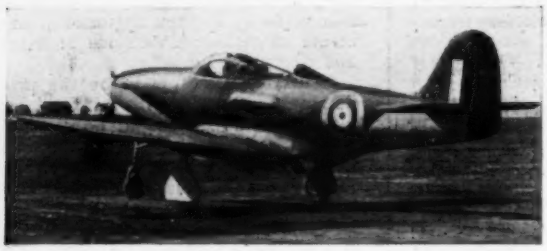
LAST OF THE BIPLANES: The Gloster Gladiator has achieved a reputation far and wide for its manœuvrability.



HAWKER HURRICANE: A wonderful example of a manœuvrable monoplane capable of using second-rate aerodromes.

FIGHTER PHILOSOPHY

(Right) The latest Messerschmitt, the Me 109F2, is fully, and rather strangely, flapped.
(Below) The Bell Airacobra has its engine amidships for three very good reasons.



loading in order to attain higher speed has resulted in aircraft with loadings of 22 to 25 lb./sq. ft. being still considered as (relatively) manœuvrable. Refinements in the way of flaps allow landing speeds as low as about 62 m.p.h. A modern high-speed fighter, on the other hand, would have a wing loading of 31 to 35 lb./sq. ft. (Me 109, 31.7).

The biplane is a little more favoured in respect to manœuvrability than the monoplane. Most biplane fighters in service have wing loadings below 20 lb./sq. ft. (Gloster Gladiator, 14.3 lb./sq. ft., Henschel Hs 123, about 18 lb./sq. ft.). However, their top speeds are now too low.

Thus, the definition of manœuvrability is purely relative. In Spain the Me 109s evaded combat with fast Republican fighters; obviously, since the Messerschmitt has a speed in the turn of 200 m.p.h., while the Republican monoplane could perform turns at speeds down to 168 m.p.h.

In aerial combats over Britain the same thing occurred. Early types of the Hawker Hurricane (wing loading 24 lb./sq. ft., top speed 335 m.p.h.) are certainly "high-speed" by comparison with the obsolete Gloster Gladiator, but equally "manœuvrable" compared with the Me 109. A good indication of the manœuvrability of the Hurricane is afforded by its landing speed, which is said to be 60 m.p.h. Obviously, therefore, in the aerial fighting over Britain the Me 109s avoided combat, as they did in Spain.

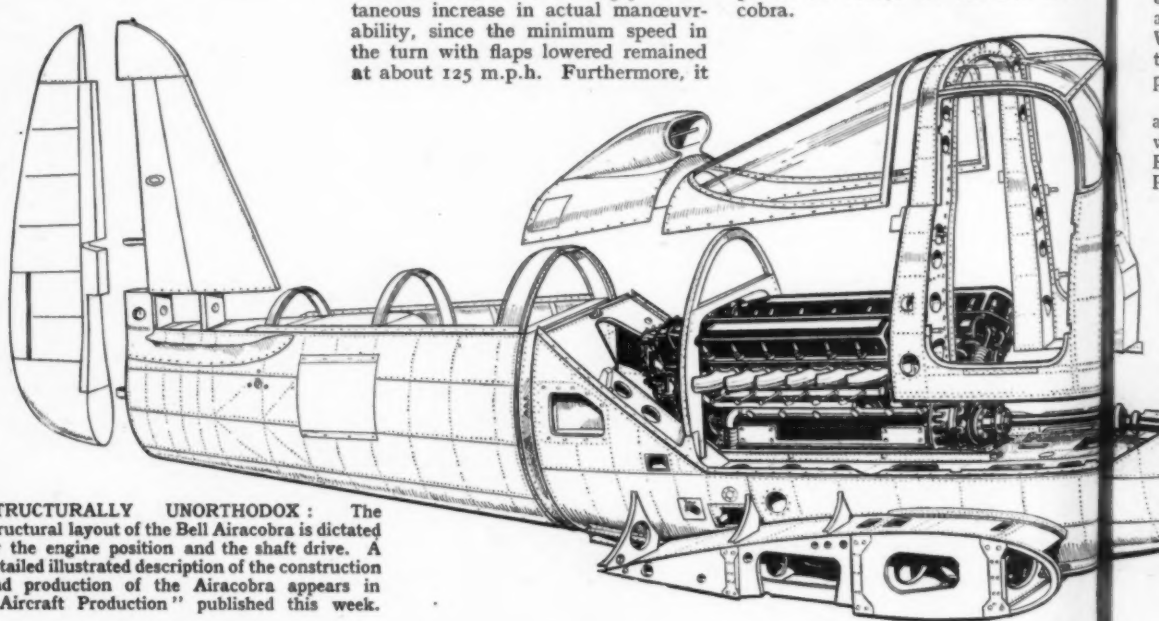
High Speed Essential

Adoption of monoplane fighters will permit development in the direction of a synthesis of manœuvrability and speed. One means of development in this direction is the provision of wing flaps and similar devices to an increasing degree. In particular it was noted on the Me 109 in Spain that the flaps could be lowered by the simple, short movement of a lever, by which means the turning power was almost instantaneously increased by 40 per cent. This did not, however, imply simultaneous increase in actual manœuvrability, since the minimum speed in the turn with flaps lowered remained at about 125 m.p.h. Furthermore, it is said that the Me 109 suffers from flutter at high speed. Nevertheless, the Me 109 design indicates the line of development of the standard, mass-produced fighter aeroplane.

It might be possible to enhance the flap effect by using the ailerons as auxiliary flaps. A device of this nature was developed in the U.S.S.R. some six years ago, and is said to have been patented by Heinkel in 1939.

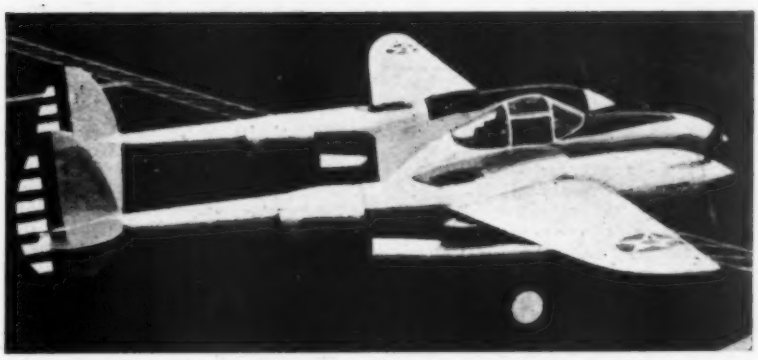
This line of development indicates that biplane and sesquiplane fighters are obsolete, and could only be revived on the basis of some entirely new technical principles.

Finally, the question has to be considered whether it is possible to confine development to some single type of fighter aeroplane, on the lines of an improved Hawker Hurricane. This question must be answered in the negative. The British themselves acknowledge that the ability to refuse or evade aerial combat, furnished by high speed, must not be sacrificed. This is shown by their recent orders placed in U.S.A. for the Bell Airacobra.



STRUCTURALLY UNORTHODOX: The structural layout of the Bell Airacobra is dictated by the engine position and the shaft drive. A detailed illustrated description of the construction and production of the Airacobra appears in "Aircraft Production" published this week.

AMERICA'S TWIN-ENGINED ANSWERS: The demand for twin-engined fighters has brought various answers and the Lockheed Lightning and the Grumman Skyrocket are two mentioned in the Russian part of this article.



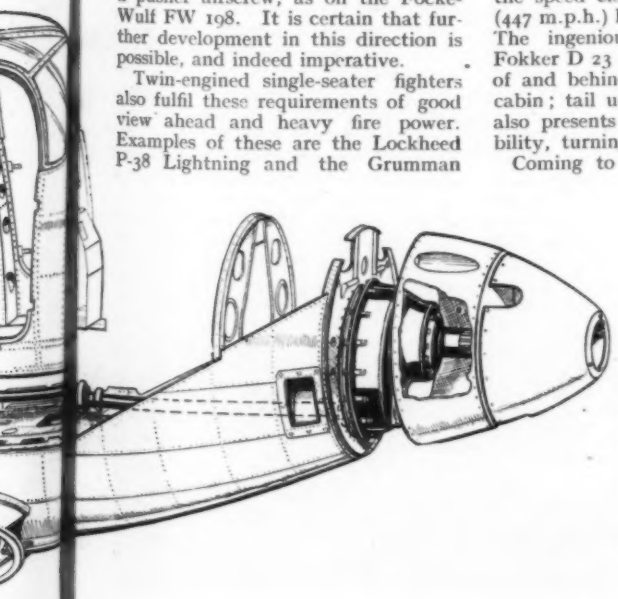
The Germans, though having a preponderance in numbers and an advantage in speed, absolutely failed to obtain mastery over the British air forces. They suffered disproportionate losses and abandoned operations.

Another factor favouring the retention of manœuvrable fighter types lies in the possibility of their employment in co-operation with ground forces. The fighter units would in such case be attached as corps troops to the ground forces, and having to make use of primitive and improvised forward aerodromes, a manœuvrable machine of low landing speed would be particularly useful.

Two Types Required

Thus, it would appear necessary to retain two types of fighter, while striving energetically toward the development of a simple type with the greatest possible speed range. In this regard it may be pointed out that the existing arrangement of a tractor airscrew and engine in front does not suitably fulfil requirements. The "blindness" of the single-seater fighter has become such an accustomed fact that its unsuitability is hardly realised. Nevertheless, types already exist which provide an excellent forward view for the pilot, namely, the Koolhoven and the Bell Airacobra. In these the engine is behind the pilot, and the tractor airscrew (or airscrews in the Koolhoven) carried by an extended shaft. Both types suffer from the general defect of inadequate fire power. This deficiency could be overcome by the provision of a pusher airscrew, as on the Focke-Wulf FW 198. It is certain that further development in this direction is possible, and indeed imperative.

Twin-engined single-seater fighters also fulfil these requirements of good view ahead and heavy fire power. Examples of these are the Lockheed P-38 Lightning and the Grumman Skyrocket. A similar arrangement was proposed in the U.S.S.R. some 12 years ago. The very expensive twin-engined machine might therefore be suitable for incorporating in picked units, although its advantages by comparison with the single-engined machine with a pusher airscrew are not very considerable. The turning power is very low and the possibilities of increased speed limited. For example, the Lockheed Lightning has a top speed of only 405 m.p.h. and the speed claimed for the Skyrocket (447 m.p.h.) has not yet been verified. The ingenious arrangement of the Fokker D 23 (tandem engines in front of and behind the pilot in a central cabin; tail unit on two light booms) also presents no advantages, in visibility, turning, or fire power.



Coming to two-seater fighters, we see that the single-engined two-seater is an absolutely superfluous type. Accommodation in a single-seater is already very congested, and the provision of an additional seat for the gunner will make conditions worse.

But the twin-engined two-seater fighter is better. The transference of the engines into the wings affords room for a gunner. The additional drag is compensated to a certain extent by the appreciable increase in power. In all other respects the aircraft gains by having the nose of the fuselage freed from engine and tanks.

The provision of a second member of the crew increases the utility for reconnaissance and the additional space in the fuselage allows increased tank capacity and therefore range. In the ultimate result, the two-seater fighter becomes a true multi-purpose machine, capable of the following duties:—

1. As the leader of a formation of single-seaters, making use of radio for control of the formation.
2. As an escort fighter for bombers on long raids.
3. As a spotting aircraft, shadowing enemy bombers over their own territory, and continually reporting on their movements.
4. As the most suitable type for "attack" operations.
5. As a safe and convenient reconnaissance machine for the most important and dangerous tasks.

The summary proves and confirms the necessity of including the twin-engined two-seater among fighter types. This contention is supported by the experience of the Messerschmitt Me 110. However, their number, relative to the total fighter force, should never be great. Apart from the cost, the single-seater fighter is hardly likely to fall behind the two-seater in the matter of speed, and is infinitely

FIGHTER PHILOSOPHY

superior to the latter in manœuvrability. A two-seater, if of obsolescent type, would need considerable protection by escorting single-seaters. Therefore, the two-seater should be designed for the maximum possible top speed.

For the same reason, replacement of the twin-engined fighter by a multi-purpose machine is undesirable. The same Me 110 with its speed of 379 m.p.h. is absolutely superior to its

œuvrable single-seater monoplanes, and long-range two-seater twin-engined machines.

3. For general aerial combat, it would be desirable to replace the existing single-seater fighters by a pusher-airscrew type, subject to suitable technical development of this arrangement.
4. More attention should be paid to the further mechanisation of the wing by means of flaps and other devices to combine the qualities of manœuvrability and high speed in a single type of fighter.
5. Night fighters and high-altitude

building aircraft had always thought in terms of the vehicle, and realised that perhaps we were sticking out necks too far when we began to think in terms of fire-power instead!

We knew very well that with horse-power, size and wing loading the same, there was no reason why three or more capable manufacturers couldn't build aircraft which would have about the same high speed, ceiling, rate of climb, manœuvrability and other performance characteristics.

We looked back over history, and saw countless examples of the truth that victory most often comes to the

TANDEM TWIN : The Fokker D-23 is a unique design for a twin-engined fighter.

FIGHTER-BOMBER : The Messerschmitt Me 110 is a very successfu' twin-engined fighter and fighter-bomber design.

equivalent, the "high-speed" Douglas DB7, Martin 167W, and Breda 88, lifting up to one ton of bombs, but barely attaining a speed of 310 m.p.h. Even the fighter-bomber Me 110 Jaguar, carrying a small bomb load, does so without detriment to its other qualities. Consequently, the Me 110s can approach their targets in daylight, whereas the British "fast bombers" are still obliged to work at night.

Finally a word may be said on night and high-altitude fighters. Both types are indispensable, since in the face of vigorous enemy defence, operations must be more and more transferred to the period of darkness or up to high altitude. The struggle for altitude and rate of climb has not yet commenced between the R.A.F. and the *Luftwaffe*, but is inevitable as soon as all possibilities for the increase of horizontal speeds have been exhausted. Apparently this should be possible by adaptation of existing types.

Conclusions

1. Fighters of all types should be designed exclusively for aerial combat; any other function should be subsidiary.
2. Three standard fighter types are necessary: high-speed and man-

types can be obtained by adaptation of existing basic types.

An American Conception

Now we see how Lawrence Bell, the eminent American designer, looks at the fighter:

During the six years at Bell Aircraft Corporation in which we have been building aircraft, we have always tried to understand completely the problems involved in fighter construction before we began building the ships. In other words, we analysed the philosophy of, and the reason for, fighter aircraft, and then set about the task of building craft worthy of the name of fighter.

We tried to think of the aeroplanes we wanted to build in military terms What they should be able to do, assuming, of course, that they were equal to or better than other craft with respect to high speed, ceiling, rate of climb, manœuvrability, etc. We realised that many other people

side with the greatest fire-power. When Hannibal crossed the Alps with a circus parade of elephants, he was bringing into play against the defending Romans a brand of fire-power which was devastating. When William the Conqueror stormed the heights of Senlac in 1066, he was utilising fire-power which was more than King Harold's warriors could withstand.

In a very real sense we at Bell Aircraft were reading history for the lessons we could apply to military aircraft. We were thinking in terms of fire-power.

We asked ourselves what a fighter should be able to do. Three qualities were vital to a successful fighter: (1) sufficient fire-power; (2) improved landing and ground-handling characteristics; and (3) greater vision.

With respect to No. 1, we knew that no bigger bullets were needed to put a man out of action in 1937—when we began the Airacobra—than during the previous World War. But we en-

DOUGLAS DB-7 : In the Boston version this design is an attack-bomber ; as the Havoc it is a night-fighter.

visaged a fighter which would be able to do more than injure or kill unprotected men. We thought of an aeroplane which would be able to fire an explosive shell powerful enough to cope with *panzer* divisions and vanquish the biggest bomber.

In the present war, according to the picture we had back in 1937, fighters would have to operate under far less ideal conditions than those provided by super aerodromes. They would have to be able to get off improvised fields. They would have to take off cross-wind, if necessary. And they would have to operate at night without the aid of floodlights.

We knew fighter pilots, when fatigued from the strain of combat, would need to be relieved as much as possible from the responsibilities which conventional landing gear presented. The only answer to Item No. 2 was tricycle landing gear.

The demand for speed and more speed had resulted in bigger engines. And the bigger engines had robbed fighters of a characteristic we considered vital: good visibility.

Automatic Range Computer

The key to all three of these problems was the extension drive shaft. Manufacturers in 1937 probably were agreed that such a drive shaft installation was possible, but they had hesitated to risk the effort and expense of developing it. Moreover, it is doubtful if many designers visualised the full value of the threefold benefits.

To a very important degree the Airacobra as it flies to-day, hurtling through the air with a 37 mm. shell-gun, is due to the Air Corps. Back in 1937 we entered two designs in the Air Corps fighter competition. One was substantially the Airacobra; the other was a more conventional model, with the engine located in front of the pilot. It was the Air Corps which chose the Airacobra design.

Before explaining in more detail why we designed the Airacobra so as to make use of the drive shaft, let me go back a little to the development of the Airacuda. In this bi-motored multi-place fighter we had utilised drive shafts, though these were comparatively short. With respect to fire-power, the Airacuda was outstanding. Details of the armament and fire-control arrangement are still restricted, but one may say that this craft incorporated a very accurate range-finding device, connected to an automatic computer, for the firing of the two 37 mm. shell-guns carried.

The function of the fire-control equipment is essentially the spotting of the target in the line of view of the telescope, which is part of the range-finding equipment, to determine the range of the target from the gun. An automatic and continuous adjustment of the gun to fire to the target is made electrically, with the proper corrections made in the gun pointing by the automatic fire-control computer device. Compensation is also made for variation in relative positions during firing, and allowance for time of flight of the shell from the gun to the target. This fire-control equipment was developed in co-operation with the Ordnance Department, under the direction of the Air Corps. Besides this, the Airacuda incorporated power-driven turrets!

THE AIRACOBRA is now reaching Britain from U.S.A. Though primarily a fighter, its heavy 37 mm. shell-gun may qualify it for ground attack duties against tanks. It is said to have eight machine guns as well.

Shellguns of 20 mm. weren't big enough to satisfy our requirements, and Air Corps tests had convincingly demonstrated the superiority of the 37 mm. projectile. Even if we had wanted to make use of the plan adopted by the Germans, there was no engine in the United States or Great Britain which would accommodate any shell-gun, much less a 37 mm. So we had to place the engine somewhere else than in the nose of the ship.

Then we wanted tricycle landing gear. This would be impossible if the engine were located in the nose.

With respect to vision, we were again stymied when we sought to design a fighter with the engine forward.

In designing our engine placement behind the pilot we moved forward into the nose the reduction gear, which is usually an integral part of the engine. In other words, the reduction gear was placed directly behind the airscrew, with power being transmitted from the engine by the drive shaft.

What was the cost, in weight, for this advance in aircraft design? Precisely 50.7 lb. The drive shaft, 10ft. in length, weighs but 40 lb., while the single centre bearing weighs 10.7 lb. We gave the drive shaft hundreds of hours of testing, on the block and under actual flight conditions, and its smooth functioning was beyond even our hopes. We designed the installation of this drive shaft so that during a terminal velocity pull-out of 12 *g*—more than any pilot could stand—the nose of the plane would deflect up to 1¼in. But the drive shaft was engineered so that it could take a deflection up to 2in.

Let us consider for a moment the rewards gained from this engineering innovation in aircraft design. With respect to the 37 mm. cannon, we had shot into the sky a weapon capable of coping with the most potent weapons of mechanised cavalry divisions and mosquito boats. We had equipped an aeroplane with a weapon firing projectiles against which it was impossible successfully to armour-plate other aircraft. Nor could any leak-proof petrol tanks be installed which would withstand the force of its explosive shells. In short, we had lifted anti-aircraft and anti-tank guns into the air!

Easier Landings

Our tricycle landing gear gave us a fighter which could use four-lane highways for take-off and landing purposes more safely than many conventional pursuit planes could use a mile-square airport. In the event of war-time conditions, when landing fields would be bombed, or for emergency landings, our tricycle-geared craft was still safe to bring to earth. This applied no less strongly to night operations. It is possible to come in for landings at speeds varying from 80 to 140 m.p.h. For the first time an aeroplane had been developed in which the pilot didn't have to run out of altitude and speed at the precise moment he reached the proper spot on his landing field. And, of course, ground looping has been eliminated.

Four years ago, I believe, many builders of aircraft confused the question of fire-power. In their effort to improve their products they thought only in terms of the number of small calibre guns.

Opposed to this opinion, we have always felt that the important thing was the size of the projectile—the force of the striking blow. I suppose one could take all the 16in. guns off a battleship and in their place substitute perhaps 2,000 machine guns of .30in. But the effectiveness of the dreadnought would obviously have been lost during the transfer. And I am willing to concede that it might be possible to bring down a multi-motor bomber if you fired enough rice at it. But this procedure would be far more difficult than the firing of a well-aimed 37 mm. projectile weighing 1.25 lb.

The .30in. machine-gun certainly had its place in the first World War but not in the present one.

AFTER THE WAR

A Reply to "Air Vice-Marshal"

By MAJOR F. A. de V. ROBERTSON, V.D.

IN last week's issue, in his comments on my article "After the War" (published in *Flight* on August 28th), "Air Vice-Marshal" attributes to me a "masterpiece of muddled thinking." Attacks on the mental capacity of an opponent do not carry anyone very far in an argument, so I will pass over that compliment and proceed to discuss the points he raises.

I wrote "at the very least the Army must have first call on a minimum number of squadrons suitable to carry out all the operations required by the Generals." My critic calls this "a proposition which is itself highly controversial and, in this wider context, strangely irrelevant." It may be controversial—why not? I stick to my opinion, and everyone else is free to hold his opinion. And I also wrote: "This Command (i.e., the Fighter Command) most certainly ought to be in complete charge of all elements of air defence, the A.A. guns, and the searchlight battalions," etc. There are probably some people who would consider this proposition also to be "controversial," but "Air Vice-Marshal" raises no objection to it. In fact he wrote: "Fighter Command must obviously remain and should include, not only the other components of air defence, but also," etc. Irrelevant? Well, I do not agree with "Air Vice-Marshal"; I think the point is very relevant to a consideration of our organisation after the war.

The Bomber "Pool"

He seems to ask what I mean by saying that the Bomber Command must maintain its function "as a pool or reserve." I will try to explain. In the present war the Bomber Command has many times attacked special targets for the benefit of both the Navy and the Army. Bombing the German troops as they advanced towards Dunkerque was one instance, and attacking the German fleet in the Heligoland Bight was another. I think that a body which can reinforce in more than one direction when a special effort is needed can justly be described as a reserve; and we have all heard the term "pool of pilots" which has a similar implication.

"Air Vice-Marshal," quoting my expression "a strong, independent striking force," says that the word "independent" is meaningless and misleading. It was applied by the Air Ministry in 1918 to an Air Force body in France which was not under the command of Lord Haig. I used the word in that sense, and thought that the meaning would be clear to all. To my mind, when the Bomber Command is engaged on operations not requested by the Navy or the Army it is acting independently. But why "misleading"? There I fail to understand what "Air Vice-Marshal" means.

I will pass over his sneer at my use of the time-honoured word "coasts." Perhaps I may sometimes have been guilty of writing that "the fleet sailed." Old expressions die hard.

"Air Vice-Marshal" objects to my saying that in the future each Overseas Command must be considered in the light of local conditions, and remarks "surely we have learnt by now that there is nothing local about air power." I think he means that if there is a chain of air bases any point can be quickly reinforced. But it has recently been explained to us all that to get aircraft to the Middle East (to say nothing about Allied countries like Greece and Russia) has been a slow and difficult piece of work. It is also a slow business to transport the ground impedimenta of a squadron. Now, I cannot guess what position will be held after this war by France and Italy in Africa or by Japan elsewhere, so I cannot suggest what degree of strength we ought to station permanently in the Middle East or in the Far East. I do not in the least differ from "Air Vice-Marshal" when he says: "Overseas Commands must never be allowed to sink back to the ludicrous level of 1939," and there was nothing in my article which suggested that I held such a view. But I stick to it that these points must be considered in the light of local conditions.

The main point of difference between "Air Vice-Marshal" and myself is that he considers that a strong R.A.F. bomber force will be the best way to prevent Germany from re-arming, and that I doubt it. I do not wish to be offensive in any way, but I really do consider that he has misunderstood what I wrote; and after reading my article over again very carefully, I do not think there is any reason why it should be misunderstood. Most certainly I did not overlook (as he says that I did) the necessity of preventing the resurgence of the *Luftwaffe*. I wrote: "If the Eight Points stand, then Europe must be knocked into shape and kept in shape by the combined forces of the British Empire and the United States of America for a considerable time to come. . . . During the period of policing we shall probably have to keep an Army in occupation of some parts of the Continent. . . ." I suggested no time limit. I made it clear that the Army must have an adequate Air Component, and that behind that there must be a reserve of bombers.

"Air Vice-Marshal" writes: "We cannot keep a great Army of occupation permanently in Europe." I consider that very probably we may have to keep an adequate Army there until we feel safe. It would be expensive, but it is cheaper to prevent a war than to have to win one. My suggestion that a small, very well equipped, regular Army would serve Britain's needs was qualified by the preceding words, "But, in general," which I think indicated with sufficient clearness that the opinion applied to the time after the danger was past. And even after it has passed, though pacifists and exponents of disarmament may call me illogical, I stick to it that the Navy and the Fighter Command must be kept at a level of high power.

That does not mean that I "envisage post-war conditions in which we have still powerful potential enemies in Europe." My critic has himself accepted my contention that the Fighter Command and the Navy must remain. It does mean that I believe in paying insurance premia.

The Lesson of Munich

I admitted in my article that the threatening existence of the *Luftwaffe* had much to do with causing the humiliation of Munich at a time when other Powers were weak. So far as Britain is concerned, my belief is that it was the unpreparedness of the Fighter Command (including A.A. guns, etc.) rather than of the Bomber Command which had the greater influence. In fact I more than doubt whether the possession of a strong bomber force at that time would have made any difference. I explained why I believed that the *Luftwaffe* inspired more terror than British bombers would do, namely, because the latter would not make deliberate attacks on civilians. "Air Vice-Marshal" may think that he answered that argument adequately. He said that, though we aim at military targets, we cannot help killing some civilians by accident, and he evidently implied that this would deter an aggressor. I am not persuaded that a man of the Hitler type would be deterred by such a consideration. I doubt if such a man would even be deterred by the thought of deliberate attacks on his civilian nationals.

However, on the effectiveness of an independent (I stick to the word) bomber force I do not think that any amount of arguing would bring "Air Vice-Marshal" and myself into agreement; so we had better agree to differ. I am sure that he will survive it.

HERE AND THERE

Capitol Airport

BIGGER than New York's La Guardia Field, the new airport at Washington, D.C., was opened recently. A very modern administrative building with a glass front looks out on the huge 729-acre aerodrome. This airport was constructed to replace the former one, which was regarded as much too small for present-day needs.

Air Cadet Corps in Australia

ADMINISTERED by R.A.A.F. Headquarters, the Royal Australian Cadet Corps has been formed on the same lines as the A.T.C. here. Mr. W. A. Robertson, deputy chairman of the Victorian State Rivers and Water Supply Commission, has been appointed director of the Corps with the rank of Group Captain. He was flight commander in an Australian fighter squadron in the last war. Boys are eligible to join when they reach the age of sixteen, pass a medical examination, and indicate that it is their intention to join the R.A.A.F. at the age of eighteen.

More B-19 Data

THE gigantic Douglas four-engined B-19 bomber, whose recent successful test flight we reported, is said to have cost between £800,000 and £900,000 and to have required 700,000 engineering hours for design and construction. The two main landing wheels are 96in. in diameter and each wheel assembly weighs 2,700 lb., which is considerably more than one ton. The airscrews on the 18-cylinder 2,000 h.p. Wright Duplex Cyclones are three-bladed Hamilton Hydromatics of 17ft. 1in. diameter and 696 lb. in weight. Pitch-changing is done by hydraulic means and the pumps supplying pressure for feathering are driven by two alternating-current motors. This alternating current is obtained from two generators driven from petrol engines. The same generators also supply power to operate the landing gear and wing flaps.

Crew of Ten

TURNING to the question of crew, the B-19 has six men in the operating cabin, which is sound-proofed, heated and ventilated. The chief pilot is on the left with the second pilot on the right. The commander is slightly to the rear. In addition, the flight engineer, radio operator and navigator are in the cabin, which is referred to as the "bridge deck." The remainder of the ten-man crew, the chief mechanic and three relief members, have stations elsewhere in the aeroplane. On operational flights, though, of course, the first B-19 is only intended for experiment, the crew would number about eighteen.

Fuel capacity is 11,000 U.S. gals. (approximately 920 imperial gals.) and bomb load is given as 18 tons, although it is not stated if this can be carried with the maximum fuel load. As a troop carrier, the B-19 can accommodate 125 fully equipped men. Its total loaded weight is 164,000 lb. Cruising speed is given as 186 m.p.h., but on its first long flight the B-19 was not flown faster than 150 m.p.h.

Names to Live Up To

TWO West Country volunteers who recently enrolled in the R.A.F. are named Lloyd George and Winston Churchill. The latter, moreover, has a younger brother named Randolph!

Determination

A YOUNG American from Chicago, now training as a pilot in the R.A.F., spared himself no effort in his determination to reach this country.

He hitch-hiked from New York to New Orleans, where he joined the crew of a Norwegian tanker bound for Le Havre, describing himself as a Canadian. But the French police would not let him land, so back he had to sail to Venezuela, where his ship collected a cargo of oil and sailed for Toulon.

While his ship was lying in Toulon harbour, Italy entered the war and France collapsed, so the Norwegian captain ran across to Oran. Here the "Canadian" left the ship and, after numerous adventures, reached Gibraltar, from where he obtained passage to England.

This young American has variously been a soda-fountain "jerker," railway hand, factory timekeeper, lorry driver, margarine salesman and theatre usher.

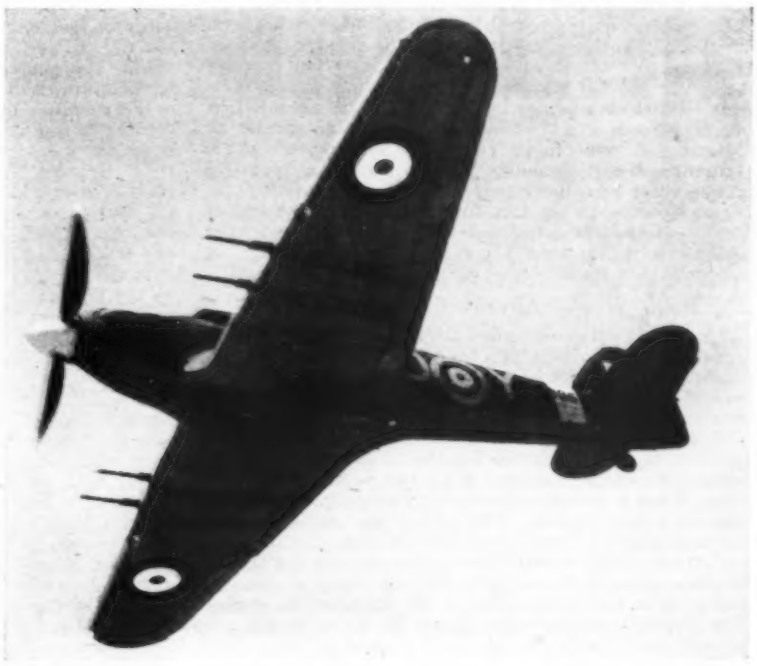
Back to the Land

QUANTAS AIRWAYS, Australia, started as a service of landplanes across Queensland and the Brisbane-Darwin run was their most important route. Now the company is best known for its flying-boat service between Singapore and Sydney, although it has always kept up one of its landplane routes between Brisbane and Newcastle Waters. But the Brisbane-Darwin run with a Lockheed Electra has been restored to relieve the flying boats. The time-table is once weekly and the trip is spread over two days.

Aero Engines in Tanks

THE Wright 450 h.p. nine-cylinder Whirlwind is being used as the motive power for the Chrysler M-3 tank now being produced at several factories in U.S.A. The Wright Aeronautical Corporation reveals that when the choice of engines was made there were two types available, the liquid-cooled marine engine and the air-cooled radial aero-engine.

The marine types, being of low speed, were bulky and took up too much room in the tank, leaving insufficient space for the crew and armament. The Whirlwind has a diameter of only 45in. The M-3 tank is known as a medium type and weighs 28 tons. Its armament is one 75 mm., one 37 mm. anti-aircraft, and several machine and sub-machine guns.



HURRICANE II: In addition to fitting a later type Merlin engine of greater power, the Hurricane II has considerably increased armament. Some are fitted with 12 machine guns, while others—as shown in the photograph above—have four 20 mm. shell-guns.

ICE FORMATION*

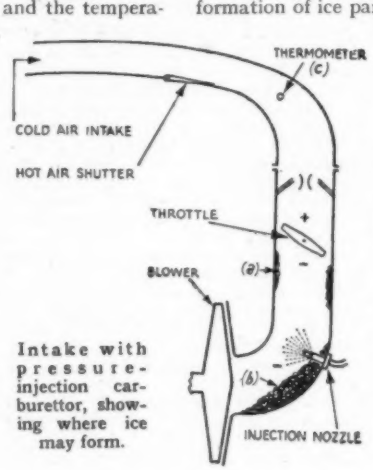
The Author Points Out That Ice Can Form in a Pressure-injection Carburettor

By "JINAIR"

CARBURETTOR ice, most mean and evil of the three types of ice formation affecting aircraft, has undoubtedly been prominent among the causes of those unpleasant announcements which start, "Missing, believed prisoner of war." It is important, therefore, that all pilots—and flight engineers, when carried—should be thoroughly familiar with the danger of carburettor ice and the means provided to combat it. They should be provided with data concerning the temperature drop due to vaporisation at various throttle settings, and the temperature rise which can be obtained on "Hot Air" at various powers, particularly at low powers during descent.

But it is not the purpose of this article to cover this comparatively old ground. Instead, the icing characteristics of the new pressure-injection carburettor will be discussed.

Originally it was reported that the pressure-injection carburettor was entirely ice-free and that no pre-heated air intake would be required, but merely a secondary *protected* scoop. While, with perfect care and attention, it might be possible to operate with such an arrangement, the experience which is now available makes it clear that, in addition to the "Cold Air" intake, a good "Hot Air" intake is necessary. This is now provided on all engine installations in which this carburettor is used. The amount of pre-heat varies, however, with the various installations.



Intake with pressure-injection carburettor, showing where ice may form.

The pressure-injection carburettor itself has already been described in this paper. It consists of a means (impact tubes and venturi) of measuring the mass of air entering the engine, and of metering the fuel in proportion. This metered fuel then passes, under pressure, to an injection nozzle, whence it is "atomised" into the air stream at a point just prior to its entry into the blower. This "atomising" or "spraying" causes a smaller evaporative cooling effect than the vaporising of the conventional carburettor, owing to the fact that only part of the fuel is vaporised, and the remainder enters the blower in solid globular form. It then vaporises under the "heat" of compression in the blower where it can do no harm.

Advantages

Thus it can be seen that the pressure-injection carburettor has an advantage over the conventional type. Moreover, it does not have a constriction in the form of a venturi, necessary on the conventional carburettor—which causes adiabatic† cooling in its wake due to expansion.

Now although it has these advantages, the pressure-injection carburettor has two perfectly good causes of ice formation which together give quite serious results. First, it has a throttle which, when partially closed, constitutes a constriction. This causes the cooling of the air that passes it, due to the low pressure and resultant expansion. This cooling is only partly offset by the heating due to compression before the throttle, owing to the fact that part of this heat is lost to the walls of the intake. The throttle can, therefore, cause ice when moisture is present, particularly at small throttle openings.

The second cause of ice, evaporative cooling, has already been mentioned. It results in ice formation between the nozzle and the blower at *b* in the diagram. Experience now shows that ice will form in the pressure-injection carburettor when rain or moisture is present at temperatures between −1 deg. C. and +16 deg. C.

The water enters with the air at above freezing point, but is cooled when passing the throttle and at the point of entry of the fuel. This cooling is probably aided slightly by evaporation of the water itself, particularly in the final bend of the intake where, losing its own velocity, it has the high-speed flow of air over it. The net result is the formation of ice particularly in the final bend of the intake (at *b* in the diagram). Above +16 deg. C. the cooling does not appear to be sufficient to cause ice, but it is wise to accept this with some caution.

Now the only protection provided against ice is a protected intake (behind the cylinders). This gives a pre-heat temperature rise of 30 deg. C. to 50 deg. C. over outside air temperature at normal cruising powers—with more on the climb and *considerably* less on the descent. Double-row engines with cowling gills closed give, of course, the biggest rise. Some installations include an intake temperature thermometer, but—impossible though it may seem—others do not!

It has been found in practice that if a simple rule is followed in the application of "Hot Air," the formation of ice in the pressure-injection carburettor can be almost completely avoided. This No. 1 Rule is simply: *Run on "Cold Air" intake at all times except when in rain or moisture at outside air temperatures of −1 deg. C. to +16 deg. C., then "Hot Air" should be used.* The amount of "Hot Air" used depends on the temperature rise available. On those engines which have only a small pre-heat rise "Full Hot Air" should be used. On the better pre-heaters, however, this might be too much for the engine—and it is therefore necessary to set the "Hot Air" shutter so that the intake temperature (measured at *c* in the diagram) is +30 deg. C. to +35 deg. C. But there is one very important point to remember: the temperature rise due to "Hot Air" at a constant power and air speed is less when snow or ice is present than air with no such solid precipitation. This is due to the fact that not only has the air temperature to be raised but also that of the moisture present, which also has to be changed from its ice state to its liquid state. This change of state from ice to water requires, of course, a very large *quantity of heat*. Thus, it can be seen that the total *temperature rise* is much smaller than when air alone is heated. As an example, suppose that the outside air temperature is −1 deg. C. and that "Full Hot Air" at cruising power level flight gives a rise of 40 deg. C. in air with no precipitation. If, however, moderate to heavy snow were present, the rise might only be half that figure, giving an air intake temperature of +19 deg. C. If, now, power is reduced, and therefore the amount of pre-heat, there is the danger that the resultant air intake temperature will fall to within the danger zone of −1 deg. C. to +16 deg. C. with moisture present—and ice would result. Hence we have rule No. 2: *Hot air is applicable only when rain or moisture is present and not when snow or solid ice is present.* This is not really another rule, but merely an amplification of rule No. 1.

Finally, let us examine the two commonest examples of how carburettor ice can be formed by failing to adhere to rule No. 1. The first case is simply that of flying into

* This article does not apply in cases where the turbo-blower is fitted.
† "Adiabatic" means drop of temperature without loss of heat.

ICE FORMATION

rain with an outside air temperature of about +8 deg. C. on "Cold Air" intake. Carburettor ice forms, and this can be detected by a reduction of boost pressure, or rather, by inability to obtain high boost pressures. Incidentally, it should be remembered that at small throttle openings ice can form to a serious degree before it starts to reduce boost and therefore to become noticeable. If an exhaust gas analyser is fitted, it gives an early indication of ice formation by showing a richening of mixture. The immediate action in this case is to change over to "Full Hot Air"—which, if the engine is still hot, will soon remove the ice.

The second common example of ice formation in the pressure-injection carburettor is the case where the aircraft flies into snow, sleet or hail on "Hot Air" intake, with outside air temperatures between about −5 deg. C. and −20 deg. C. Under these conditions "Hot Air" gives a temperature rise of only about 10 deg. C. to 20 deg. C. plus melting the snow or ice. Thus water enters the carburettor at a temperature within the −1 deg. C. to +16 deg. C. danger zone, and ice forms. The remedy is to go over to "Cold Air." To remove the ice which has formed recourse can, if necessary, be made to backfiring (caused by the use of the cut-out and mixture control and/or by the ignition switches), but in cases where the engine is still functioning the ice will soon disappear due to evaporation. In closing, let me repeat the rule: Run on "Cold Air" intake at all times except when in rain or moisture at outside air temperatures of −1 deg. C. to +16 deg. C., when "Hot Air" should be used.

AMERICA IS BUILDING

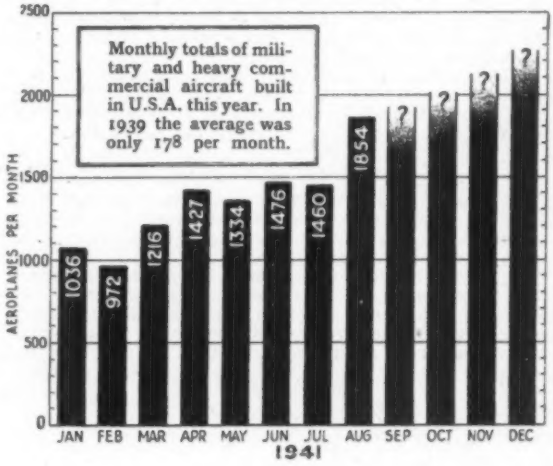
Aircraft Production Reached 1,854 During August : The Curve is Still Rising

THE month of August showed a marked rise in the output of military and heavy commercial aircraft in the United States, a total of 1,854 being constructed. This is 394 greater than the total for July, a very big increase. But judgment of the rate at which American production is increasing cannot be formed on a comparison of two months only, and it is necessary to look back some time.

Average monthly production during 1939 of this same class (military and heavy commercial) was only 178, though, including all types of aircraft, the figure was 488 per month. But Lord Beaverbrook's statement in July, 1940, that he had made arrangements with U.S.A. "to put into immediate production aeroplanes for our account up to a total output of 3,000 per month" was evidence that we would, at some time, obtain great help from over the Atlantic. So under the stimulus of great urgency the monthly rate of 178 of 1939 had risen to the total of 799 military and heavy commercial aircraft for the month of December, 1940, a great increase for this first sixteen months of the war.

But the monthly total has kept on rising since December of last year, and now has reached the impressive figure of 1,854. How this rise has taken place is shown in our graph, the average for the eight months of this year being 1,347.

Naturally, the rate of rise has not been quite constant, and production was almost steady for the four months, April to July. Examination shows that the average rate of increase in the production rate is 110 per month; that is to say, in each month 110 more aeroplanes were made than in the previous month. If this increase is maintained to the end of this year—and there is no reason why it should not be—the rate should then be 2,200 per month. For readers who are interested in watching the rise of



American production, the graph has been prepared in such a way that they can add to it as the figures for the later months are released.

If the rate of increase is maintained for still longer, a monthly rate of 3,000 will probably be reached about July 1942, but the arrangement was that we receive about half of this output, not the whole of it. Now, with Russia numbered among the Allies, a certain amount of American production must go to her, for this field of conflict is a most important one, and much of Germany's menace must be met on Russian soil if she is to be defeated.

JET PROPULSION

(*Continued from p.* 192.)

As shown in the diagrammatic illustration, the plant is contained in a shell A, having a forward intake and a rear propulsion nozzle, which forms the main air duct. The lower cycle is effected by an axial flow compressor B driven by an axial flow gas turbine C through step-down gearing D. For the higher cycle a compression-ignition engine E drives a centrifugal compressor F through gearing G.

Of the single rotor, bilateral intake type described in connection with a Whittle plant in the preceding article, this compressor draws air at the intermediate pressure from the interior of the main duct A and delivers into duct H leading to the nozzle scroll of the turbine C. By intake pipe J, engine charging air is drawn from duct H, and the engine exhaust by pipe K joins the air in duct H to form the working medium for turbine C. The effluent from the turbine is led through duct L to a rearwardly directed auxiliary propulsion nozzle.

The possibility is suggested of enhancing the propulsive efficiency by deriving some or all of the air from the boundary layer at or over any part of the structure, and also by utilising the discharged gases to modify or improve aerodynamic effects. As in other schemes, further heat may be added before final expansion by the combustion of additional fuel. This, of course, would be provided to carry temporary overloads.

(*A further article on this subject will follow.*)

Correspondence

The Editor does not hold himself responsible for the views expressed by correspondents. The names and addresses of the writers, not necessarily for publication, must in all cases accompany letters

CONTRA PROPS.

Torque Reaction from Blade Thrust

RE the query by "Mystified" in *Flight* dated September 11th, 1941, I am afraid he is somewhat confused. Counter-rotating airscrews should almost eliminate torque reaction, as it is the thrusting effort of the airscrew blades which sets up the torque reaction and not the engine itself. The only reaction in the latter is due to the side thrust of descending pistons on their power strokes.

If two separate airscrews are coupled to the same crankshaft and driven in opposite directions by means of gearing, it is obvious that the reaction of one will counteract the other. This assumes that the work done by both airscrews is identical.

With regard to engine testing for power, I do not think this is possible with a counter-rotating airscrew. In any case, power determinations when based on torque reaction are made by coupling the engine to an air or water brake. In these tests the impellor in the brake casing takes the place of the airscrew, and this causes the brake casing or engine cradle, in the case of an air brake, to swing on its mounting.

It remains to be proved whether the "twisting" of the slipstream will be entirely eliminated by the counter-rotating airscrew.

R. H. LONGE, G.E.1181.

A Question of Air Force

THE gearing between "contra-props" is such that *three* items (besides the engine) tend to rotate: each prop. and the gear mounting—the latter in the opposite direction to the engine with equal force.

"Mystified" reasons correctly in so far as "contra-props." would be impossible without introducing the third item at the hub. But it is best to realise that the torque which tends to bank the whole aircraft depends on the *air* forces on the prop. blades—nil in a vacuum for instance.

R. C. ABEL.

An Expert Explains

THE reasoning of "Mystified" is sound and his conclusions correct, but I can assure him there have been heated arguments over the point he raises. There is some confusion between the effects of various types of counter-rotating airscrews. A counter-rotating airscrew, the two parts of which are mounted each on counter-rotating shafts, each shaft driven by its own engine or own set of cylinders, would eliminate the engine torque reaction.

Equally, a counter-rotating airscrew, one part of which is mounted on the shaft and the other on the engine casing (the latter being free to rotate), would serve the same purpose, but a counter-rotating airscrew of the type under discussion intended to fit to the single shaft of existing types of engines does not eliminate or in any way affect the torque reaction from the engine.

The advance of aircraft design, although great, has not and cannot overcome the fundamental axiom that to every action there is an equal and opposite reaction. I realise that this is just a denial on fundamental grounds rather than an explanation of the statement in your article, but it is rather for those who contend that the engine torque reaction is eliminated to explain how.

HENRY C. WATTS.

[For the benefit of new readers it may be pointed out that Mr. Watts is technical director of the Airscrew Co., Ltd., Weybridge.—ED.]

No Net Aerodynamic Torque

WITH reference to the queries raised in the Correspondence columns of *Flight* for September 11th, the statement that torque reaction is eliminated by the use of counter-rotating airscrews is certainly correct. This must be the case, as any *net* reaction on the airframe can only be the reaction of an externally applied (i.e., aerodynamic) load, and since there is no net aerodynamic torque applied to the airscrew there can be no torque reaction.

In an ordinary arrangement the only load transmitted by the driven member to the engine is through the crankshaft; it is on this assumption that power measurements based on torque can be made. In a "contra-prop" arrangement, in addition to the crankshaft torque, the engine crank case has to transmit reactions from the reversing gears, the effect of which must be such as to make net torque reactions zero. If the reversing gear casing is not assembled rigidly to the crank case but mounted independently, the same argument still applies to the net torque reaction on the aircraft as a whole.

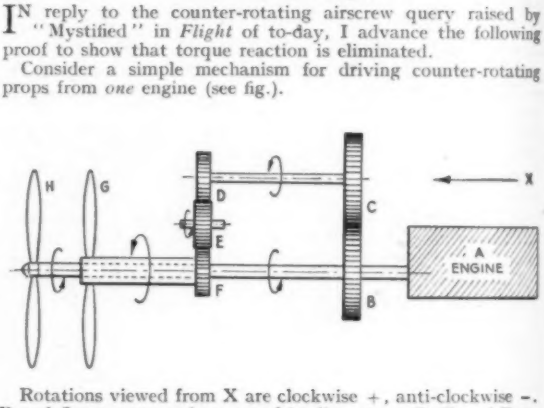
A parallel case is seen in ordinary airscrew arrangements driven through a reduction gear. In this case the power of the engine is obtained by multiplying the torque by *airscrew* and not *crankshaft* r.p.m., the difference being accounted for by gear casing reactions as with counter-rotating airscrews.

R. HADEKEL.

The ABC of Torque

IN reply to the counter-rotating airscrew query raised by "Mystified" in *Flight* of to-day, I advance the following proof to show that torque reaction is eliminated.

Consider a simple mechanism for driving counter-rotating props from *one* engine (see fig.).



Rotations viewed from X are clockwise +, anti-clockwise −. B and C are gears and are equal in diameter. D, E and F are gears and are equal in diameter.

To find direction of rotation of "A" if "G" is fixed:

First consider "A" as fixed, then the revs. will be as follows:

A	B	C	D	E	F and G
0	−1	+1	+1	−1	+1

Now subtract one rev. throughout, then

A	B	C	D	E	F and G
−1	−2	0	0	−2	0 (fixed),

which shows that if prop "G" is fixed, the engine makes −1 rev. Now if we fix "H" the engine will obviously make +1 rev., from which it is clear that if both props are fixed the engine will not turn in either direction.

Therefore, if the prop fixing tendencies (i.e., the reactions between the props and the air) remain the same in flight, their respective torque reactions at the engine must remain equal and opposite and will cancel each other.

I think that "Mystified" overlooked the fact that, due to the gearing, whatever its form, one airscrew gives a clockwise torque reaction and the other an anti-clockwise.

R. B. OSMOND, G.I.Mech.E.

[Note that the two layshafts must be mounted on the crankcase and so will apply torque to it.—ED.]

Another Explanation

LET me try to explain to "Mystified," as lucidly as my age of seventeen permits, why the effects of torque reaction *are* eliminated by counter-rotating airscrews.

He asks, "How does the engine know what happens to the torque after it has delivered it to the crankshaft?" The experienced engine will know by now that a turning moment equal to that of the engine, but of opposite sense, is to be found in the gear case that necessarily precedes this type of

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airscrew. For when a shaft delivering half the power of the engine drives, by gears, another shaft at equal speed in the other direction, the turning moment of the gear case (attached to the air frame itself, not to the spinner) exactly balances the torque of the engine. Yet no power is being absorbed because the gear case has no rotational speed.

It is meaningless to consider torque reaction and the "paddle-wheel" effect of the ordinary airscrew arrangement as separate contributors to the aeroplane's tendency to rotate. For the one cannot exist without the other; when the paddle-wheel effect is eliminated by counter-rotating airscrews, the torque reaction effect automatically disappears.

Taking an external view of the aircraft fitted with counter-rotating airscrews, it is obvious that if the slipstream is not being twisted there is nothing to twist the aeroplane unless some rotating mass is accelerating greatly.

IAN GRAHAM.

Epicyclic Example

REFERRING to the ingenious argument of "Mystified" published in *Flight* of September 11th, it is apparent that an opposition of rotation in an airscrew could not be produced by the rotation of the engine crankshaft alone and it would be necessary to use a mechanism which had some direct connection with the crankcase of the engine. Such a device would, in effect, be utilising the torque reaction of the engine, and in all counter-rotation applications this is, in fact, what occurs.

To make this argument more clear let us consider the case of a counter-rotation mechanism of the epicyclic type, where the planetary pinion bearings are fixed to the crankcase and therefore the external gearwheel must revolve in the opposite direction to the sun-wheel. Here it can be seen that the resistance of the planetary system to rotation will be in opposition to the torque reaction of the engine, and, other things being equal, will absorb that reaction. Thus, in the counter-rotating airscrews, one airscrew absorbs the action and the other the reaction of the engine.

The statement given from *Flight* is in itself misleading as, although the torque reaction to the aircraft may be said in these cases to be eliminated, that developed within the engine is not eliminated but converted. There appears to be a fallacy in the assumption by "Mystified" that power could not be measured where there is no torque reaction transmitted to the engine bearers. It seems clear that the power could still be measured from the total torque existing between the two airscrews. In actual practice, of course, power developed would probably be measured in the usual way before the fitting of the twin airscrew unit.

The theory advanced by your correspondent was put so neatly as to be bewilderingly convincing. This reply is, I am afraid, far from neatly put, but I hope it may carry some conviction though it comes from the merest layman.

E. G. PLANAS.

Measuring Torque Reaction

FLIGHT is, of course, right in stating that contra airscrews eliminate torque reaction and "Mystified" is probably confused by having seen the customary test-bed arrangement with the brake coupled direct to the crankshaft. Under these conditions it is the crankshaft reaction which is measured.

With a geared unit-construction engine the torque reaction must be measured on the output shaft no matter which way the crankshaft is rotating. Thus, if we take a Rolls-Royce type of engine with a direct drive and, say, a right hand airscrew the torque reaction is left hand. If we then add the reduction gearing, which reverses the airscrew, the torque reaction on the engine is reversed even with the crankshaft still running in the same direction.

It is surely obvious that with an engine unit operating against some external resistance (in this case an airscrew) the torque reaction upon that unit as a whole must be opposite to the resistance! If, therefore, we drive one airscrew from the crankshaft and another with integral gearing to run in the opposite direction the reaction from these two propellers will balance out and we shall not be able to measure the brake horse power of the engine by existing methods. Incidentally, in any engine with "simple" reduction gearing (as in the Rolls) the torque reaction is not about the centre of the crankshaft, but about the centre of the geared shaft.

The problem can easily be tested in any high powered car with unit construction of engine and gearbox when it will be found that the engine will tend to "heel" in one direction when accelerating in the forward gears and will "heel" in the opposite direction when in reverse, although the crankshaft is running in the same direction in both cases.

GRANVILLE BRADSHAW.

Still More Torque

IN answer to your correspondent "Mystified," may I point out that torque reaction arises from two causes: (a) inertia of the rotating parts of the engine, and transmission and propeller; (b) reaction of the air against the rotation of the airscrew.

There is no torque due to inertia in steady flight, so (a) only occurs when the engine is accelerating. (b) is the usual torque reaction, and a contra-rotating airscrew must tend to reduce it since the torques on the two halves are in opposite senses. There will probably not be exact balance because the two airscrews are obviously not operating under the same conditions, though the design of the rear one presumably allows for this.

The load presented to the engine is, however, the arithmetical sum of the separate airscrew torques, since the gearing which reverses the sense of rotation of one airscrew must also reverse the torque which that airscrew presents to the engine, so that the two become additive. The engine can therefore develop its power quite normally.

"Mystified's" conclusions arise from the false assumption that the engine is simply concerned with "producing torque" regardless of external conditions; the answer to his (rhetorical?) question "How does the engine know what happens to the torque after it has delivered it to the crankshaft?" is "By the torque reaction which is fed back to it along the crankshaft."

To the obvious objection at this point that we have now cancelled out the airscrew torque reactions, but that the engine is still producing torque against which it must be reacting, the answer is that the force between the gears driving the "backwards" airscrew provides a fourth torque reaction, balancing that of the engine, about the crankshaft.

J. R. M. VAUGHAN.

Consider Each in Turn

YOUR correspondent "Mystified" asks, does a contra-rotating airscrew eliminate torque reaction? The answer is that it does not, but balances one torque reaction against another in such a way that the engine does not tend to rotate about the airscrew axis, provided that each airscrew is absorbing equal power.

The simplest way of grasping this problem is to consider each airscrew in turn. If one could hold stationary the airscrew which rotates in a clockwise direction, the engine would revolve in an anti-clockwise direction. Similar action taken with the screw which rotates anti-clockwise would result in the engine rotating clockwise. Thus it will be seen that these two torque-reaction effects cancel out within the engine itself.

Your correspondent has become confused in his remarks concerning power measurement by assuming that because the engine has no tendency to rotate, the torque developed by the engine must be zero.

To explain this point of power measurement let us analyse the case of an engine of 1,000 h.p. having two contra-rotating output shafts.

(a) The full engine torque equivalent to 1,000 h.p. may be absorbed by a dynamometer on the shaft rotating clockwise. In this case the engine will tend to rotate in an anti-clockwise direction.

(b) 1,000 h.p. may be absorbed from the shaft rotating anti-clockwise. Now the engine will tend to rotate clockwise.

(c) 500 h.p. may be absorbed from each shaft. In this case the engine crankcase is subjected to opposing torque reactions equivalent to 500 h.p. each, and so does not tend to rotate in either direction

Hence, although there is no torque reaction external to the engine crankcase, there is still torque equivalent to 1,000 h.p. in the two shafts.

C. W. UDALL.

Or, in Other Words . . . .

YOUR correspondent "Mystified" seems to be rather confused in his ideas of the torque reaction of an engine airscrew combination.

He states, "The engine is simply concerned with developing a certain torque and therefore tends to rotate in a certain direction (the oppposite)." This is so because the torque of an airscrew is the moment of resistance which opposes the engine torque. In other words, a certain torque is needed to

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turn the airscrew at a given r.p.m. This torque is supplied by the engine and since action and reaction are equal and opposite a torque or turning moment is exerted on the engine, tending to rotate it in the opposite direction. So much for the single airscrew. In the case of single engine-driven contra-rotating airscrews the engine torque is divided equally between the two sets of blades. Therefore the turning moment exerted by the front blades will be exactly counterbalanced by the turning moment produced by the rear set and torque reaction on the engine and aircraft will be eliminated.

M. S. SPICKERNELL.

Contra Proposition

WITH regard to torque reaction in counter-rotating airscrews, your correspondent "Mystified," is surely correct in questioning your statement.

Whatever the airscrew design, the engine must have a torque reaction on its fixings. The fallacy can be explained by remembering that the front airscrew, say, rotating in a clockwise direction, produces a counter-clockwise torque in the engine supports; but the rear airscrew, though rotating in the opposite direction to the front, produces also a counter-clockwise torque owing to the gearing necessary for its difference of direction of rotation. Hence the torque reaction on engine supports is the sum of the individual torque reactions of each airscrew.

As your correspondent says, the air-stream is straightened, control improved and greater engine-powers capable of being handled by counter-rotating airscrews.

CHARLES W. PARRY.

A Rowing Boat Analogy

OBVIOUSLY your correspondent "Mystified," writing in your issue of September 11th, has confused the difference between the internal thrust set up by the initial torque of the engine, and the external reaction resulting from the force of the rotation of the airscrew blades. (Neither of these forces are identical with the slipstream.)

Cutting out the technical jargon, it is rather like an oarsman rowing a boat with one oar—the lopsided thrust being counteracted by the tiller to produce motion in a straight line. Naturally it is better for the oarsman to use two sculls and obviate the necessity of counteracting the eccentric couple with the helm; but there is still a reaction set up in the rowlocks and transmitted from them to the structure of the boat. Without such a fulcrum the power from the rower's arm could not be transmitted to the water.

Any kind of engine or conversion unit (as an electric motor) when giving a power output must set up an equal and opposite reaction, and any rotary thrust reaction is torque. Even in a system of jet reaction propulsion there is a torque reaction set up by the engine in driving the superchargers, and this force sets up an internal structural load. Such loads are principally the business of the stressman.

On the other hand the torque reaction set up by a single uni-rotating airscrew results in an excessive drag on one undercarriage wheel during take-off, an unequal distribution of lift on the aerofoils, and a tendency to impair the characteristics of stability and controllability of the aircraft in flight. This is rather the concern of the aerodynamical theorist.

The conventional type of single engine airscrew combination has a tendency to revolve the engine in the frame, and/or a tendency to revolve the entire aircraft around its airscrew. It also develops a rotary slipstream.

Among the very considerable advantages of contra-rotating airscrew installations (apart from reduced blade length, which gives easier stressing, improved ground clearance, decreased gyroscopic effect and what not) is the straightening of the slipstream and the cancelling out of the airscrew torque—so that the aircraft has no longer any tendency to revolve in the air against its airscrew.

There remains, of course, the torque reaction which tends to revolve the engine around inside the airframe, but this natural phenomenon of all rotary machinery is comparatively easy to deal with.

JAMES WEBBER.

JET PROPULSION

"Indicator's" Humour Condemned

HAVING read the "article" on jet propulsion by "Indicator," I wish to make strong protest. There was, to quote "Indicator's" own description of an earlier article, "a lot of nonsense and a certain amount of sense." It is my experience that nonsense sticks far longer in the average mind than any amount of sense. The consequent harm done by this article is scarcely to be exaggerated.

For those of us who are seriously and actively interested in jet-reaction motors, the greatest single difficulty has been in fighting the generally contemptuous and amused attitude of the aeronautical engineer and the general public. Of the two, the former has by far the lesser excuse. It should be known to you that the early days of flying provided much copy for writers of more humour than intelligence. Despite this fact, flying is as real a part of modern life as is walking round to the "local."

In recent issues of *Flight* you have begun a survey of existing knowledge upon jet-reaction motors. The information, so far as it goes, is interesting, but such motors as the Milo and Whittle propulsion units will carry the problem of aerial transport only a little farther. The real solution to such problems lies in the development of chemically powered jet-reaction motors, which dispense entirely with the need for indrawn air supplies.

I need scarcely point out that the Milo, Whittle, Ljungströms, and Schunter motors will all have a limiting ceiling, above which rarefaction of the air will increasingly influence the efficiency of the motor. In the case of the tone jet-reaction motor the opposite is the case, maximum efficiency only being attained in complete vacuum.

Pioneering is a thankless task, and those of us in Great Britain who have spent time and money in accumulating data upon the jet-reaction motor have had more than our share of jeers and discouragement. Nevertheless, there does exist in the files of the four British societies a considerable amount of valuable data. These have been obtained both by bench-testing and actual flight tests, and have been added to by exchange of information with the societies of Europe and the U.S.A.

Furthermore, contrary to the generally held ideas, most of the valuable work has been performed, not by "long-haired, wild-eyed inventors" or enthusiastic schoolboys, but by competent engineers, chemists, and mathematicians.

Should any of your readers desire further information, or any elaboration of the above, I shall be pleased to answer any letters forwarded to me. May I express the hope that the above will in some measure serve to draw a distinction between the limited conception of air-powered jet propulsion and the boundless potentialities of true jet reaction?

W. D. GARNER, B.Sc.

[NOTE.—Whilst fully appreciating our correspondent's enthusiasm for "true jet propulsion," we cannot agree that "Indicator's" light-hearted contribution could possibly do the slightest harm; otherwise we should not have published it. Mr. Garner is distressing himself needlessly if he imagines that anything even remotely resembling a jeer or discouragement lies behind "Indicator's" amusing discourse, and to speak of "writers of more humour than intelligence" is, to say the least, a contradiction; surely real intelligence demands, among other things, a sense of humour!—ED.]

CONTRA-PROP PITCH

What Happens to the Rear Blades?

MR. CLEAVER, disagreeing with a statement in your article of August 21st about the counter-rotating airscrew, still concedes that the rear airscrew "is working at what amounts to a slightly higher effective forward speed." This consideration, he says, would tend to make a coarser pitch necessary, but is overruled by the effect of the rotational air movement, which demands a finer pitch; but is even the former consideration a correct one? Surely as much air goes in at the front of an airscrew as comes out at the back, so to a first approximation the rearward velocity of the air is the same at both screws. However, since the screw gains a thrust, there must be a slightly greater air pressure behind a screw than in front of it, and since the same mass flows through, the velocity must be slightly *less* where the air is compressed—that is, behind the screw—than it is in front. That may seem a paradox; is it a fallacy? If not, it would seem that this consideration as well demands a finer pitch for the rear airscrew. What change is required by the fact that the air is more turbulent for the second screw is beyond the logic of a mere chemist; I hope one of your correspondents can discuss this point adequately, for I am sure the contra-prop will be the more acceptable the fewer points remain in doubt as to how and why it works.

CHEMIST.

Service Aviation

Royal Air Force and Fleet Air Arm News and Announcements

Middle East Aircraft Problems

AFTER a ten-thousand-mile journey in a Liberator, Major Gen. George H. Brett, Chief of the United States Army Air Corps, has arrived in the Middle East. Accompanied by a staff of specialists, he is making a detailed study of the requirements of the Royal Air Force on all the principal fronts of the British Empire. Gen. Brett was met by Air Marshal A. W. Tedder, A.O.C.-in-C., R.A.F., Middle East, and told newspaper correspondents that he was there "just to look around."

In the Middle East Gen. Brett will make a personal study of pressing problems relating to the maintenance and supply of aircraft equipment. According to an official statement issued in Cairo, the lack of personnel familiar with American aircraft and equipment in the war zones has made difficult the maintenance of American aircraft. Gen. Brett's personal survey will enable the Air Corps of the United States and allied military and industrial organisations to plan for the future.

Sergeant Ward, V.C., Reported Missing

SERGEANT JAMES ALLEN WARD, who recently won the V.C. and was shortly to have received his decoration from the King, is reported missing. His Wellington bomber, from No. 75 (New Zealand) Bomber Squadron, did not return from a recent attack on Germany. The bomber took off a few minutes after eight o'clock, and nothing was heard from it after a signal at a time when it was almost certain that the target had been reached.

A few weeks ago Sergeant Ward was made captain of a Wellington and given a crew of sergeants. They had already made one attack together against the battle cruisers at Brest on the night of September 13. They were an experienced crew, and most of them had made as many as 22 operational flights. They were, in fact, the crew with whom Sergeant Ward had come to his squadron from an operational training unit. But at first they worked under another captain while Sergeant Ward was serving in another Wellington as second pilot.

It was as second pilot that he was awarded the V.C. in July of this year. After an attack on Munster he had climbed out on to the wing of his bomber when flying at 15,000 feet over the North Sea in an effort to put out a fire which an enemy fighter's bullets had started. This was on his seventh operational flight.

After a short interval of leave he took part in three more attacks, still flying as second pilot.

Sergeant Ward was born on June 14, 1919, at Wanganui in the North Island of New Zealand. His father is a printer. He was educated at Tawaro School and at the Wanganui Technical College. He became a schoolmaster in New Zealand, but gave up teaching in July, 1940, to join the Royal Air Force. He was trained in New Zealand and came to England at the beginning of March, 1941. On his 22nd birthday he was making his first operational flight. He had always been interested in flying, and, from the age of 12, his hobby has been building model aeroplanes. He is unmarried.

Awards

THE KING has been graciously pleased to approve the following awards in recognition of gallantry displayed in flying operations against the enemy:—

DISTINGUISHED FLYING CROSS.

P/O. Douglas Park FOX, R.A.F.V.R., No. 149 Squadron.—One night in August, 1941, this officer was detailed to attack a target at Hanover. After flying through two electrical storms, his aircraft was hit by anti-aircraft fire, but P/O. Fox flew on. He was, however, unable to locate his target although he spent an hour in a determined effort to do so. P/O. Fox, therefore, bombed an alternative target in the town of Minden from a height of 6,000 feet, afterwards flying over the town at roof top height using his machine guns. On the return journey, his aircraft was attacked by an enemy fighter and severely damaged. P/O. Fox shook off the fighter but, later on, was attacked by another which was probably destroyed. P/O. Fox flew his aircraft back to this country, but, when some six miles from his base, the fuel was exhausted and he was forced to land hurriedly from a low height. As a result, the aircraft crashed and P/O. Fox was trapped in the wreckage for two and a half hours. This officer displayed great determination and courage throughout. On a previous occasion, P/O. Fox displayed similar fearlessness when attacking Hamburg.

NOT IN THE NORTH ATLANTIC: Members of the crew of H.M.S. Ark Royal take a "constitutional" on the flight deck. The perforated gratings in the foreground are windscreens which can be raised to shelter the deck when necessary.

DISTINGUISHED FLYING MEDAL.

Sgt. Arthur Charles LEIGH, R.A.F.V.R., No. 611 Squadron.—This airman pilot has displayed great skill and courage in operations, including fifty sweeps over enemy territory. Sgt. Leigh has destroyed two Messerschmitt 109's, probably destroyed another four and assisted in the destruction of a Dornier 17. His judgment and determination, especially in low flying attacks over Northern France, have set an excellent example.

Sgt. CAMPBELL CLARK, No. 69 (deceased).

Sgt. RICHARD SAXBY MUTIMER, No. 69 (deceased).

Sergeants Clark and Mutimer displayed a high standard of ability throughout the 40 operational missions in which they participated as wireless operator/air gunner and air observer respectively. Sergeant Clark showed great keenness to engage the enemy, using his guns with damaging effect, while Sergeant Mutimer always willingly cooperated with his pilot when the opportunity for offensive action occurred. They have damaged or destroyed three Italian flying boats, and in one machine-gun attack on an enemy aerodrome destroyed one enemy aircraft and damaged several others.

ORDER OF AL RAFIDAIN.

Whitehall, September 5th, 1941.

THE KING has been pleased to give and grant unto Wing Commander Neill Charles Ogilvie-Forbes His Majesty's Royal licence and authority to wear the Insignia of the Fourth Class (Military Division) of the Order of Al Rafidain, which Decoration has been conferred upon him by His Majesty the King of Iraq in recognition of valuable services rendered by him in the capacity of Inspector of the Iraqi Air Force.

THE KING has been graciously pleased to approve the following appointment and awards:—

M.B.E. (MIL.).

P/O. Charles Alfred PATTEN, Royal Air Force Volunteer Reserve.—One night in April, 1941, P/O. Patten was the rear gunner of an aircraft which crashed and burst into flames during an operational mission. On extricating himself from his turret, he went to the front of the aircraft, where the front gunner was alive but trapped.

Although this part of the aircraft was ablaze, and ammunition and flares were exploding, P/O. Patten immediately endeavoured to rescue his trapped comrade. By almost superhuman efforts, and with the assistance of two members of the crew, he was able to wrench the turret from the aircraft and drag the front gunner to safety. By his promptness and courage, P/O. Patten undoubtedly saved the life of this member of the crew.

GEORGE MEDAL.

Grp. Capt. John Astley GRAY, D.F.C., and Act. Sqn. Ldr. Joseph Aidan MACCARTHY, M.B., Ch.B., B.A.O.—One night in May, 1941, the pilot of an aircraft attempted to land with the undercarriage retracted. The aircraft crashed into the main bomb dump and then burst into flames. Grp. Capt. Gray and Sqn. Ldr. MacCarthy immediately went to the scene of the accident. Although there was some delay in getting the fire tender to the spot, owing to wire entanglements at the bomb dump, Grp. Capt. Gray and Sqn. Ldr. MacCarthy entered the burning aircraft and between them succeeded in extricating two members of the crew who were trapped.

By the time the first man had been extricated the fire had spread from the starboard tanks to the cabin and on to the port tanks. Ammunition, incendiaries and flares were burning in the wreckage, whilst numerous explosions erupted from the tanks. In spite of this, an attempt was made to rescue the pilot, who was still trapped at the bottom of the fuselage. He was dragged clear, but his harness still held him to the burning aircraft. Before he could be released another petrol tank burst and flames spread to such an extent that any further attempts to rescue him became impossible.

Grp. Capt. Gray and Sqn. Ldr. MacCarthy were assisted by two other officers, who both displayed great courage in their efforts. Grp. Capt. Gray received severe burns on the head and his uniform was destroyed, but he continued his efforts until overcome by the fumes. Sqn. Ldr. MacCarthy suffered minor facial injuries caused by burns, but despite this and the strain to which he had been exposed, he would not retire to his quarters until he was satisfied that everything possible had been done for the comfort of the injured. Both Grp. Capt. Gray and Sqn. Ldr. MacCarthy displayed great bravery in the most appalling circumstances.

Act. Flt. Lt. Harold Charles MORRIS and L.A/C. John Lewis GOLDSMITH.—One night in February, 1941, an aircraft, with instructor and pupil as occupants, crashed on an aerodrome and immediately caught fire. Flt. Lt. Morris, who was in an aircraft about to take off, taxied to the scene, whilst L.A/C. Goldsmith, the aerodrome ambulance driver, immediately took his vehicle to within 50 yards of the crash.

The fire tender was already there and foam was being sprayed at the base of the fire to subdue the flames sufficiently for the rescuers to approach the occupants, who were still in the cockpit. The instructor was able to release himself, but the pupil was pinned by his legs. Foam was sprayed on him and Flt. Lt. Morris attempted to extricate him, but without success. L.A/C. Goldsmith succeeded in getting his hand and arms into the cockpit and cutting away the pupil's harness straps, but his legs remained trapped and, by this time, were being burned. The supply of foam suddenly ceased, whereupon Flt. Lt. Morris and L.A/C. Goldsmith, incurring the grave risk

SERVICE AVIATION

of the petrol tanks exploding, managed with some assistance to lift the fuselage and to extricate the pupil.

Throughout this incident Flt. Lt. Morris and L.A/C. Goldsmith displayed conspicuous gallantry and disregard to personal safety. Unfortunately the pupil succumbed to his injuries.

B.E.M. (MIL.).

Sgt. Arthur Gwynne FRANCIS.—In June, 1941, Sgt. Francis, in company with another airman, observed an aircraft flying in from the sea with black smoke coming from the starboard engine. The aircraft crashed on the sand dunes about 100 yards away. Sgt. Francis ordered his companion to bring men and crash kit from a nearby unit and himself ran towards the aircraft. As he approached, the defective engine burst into flames and a dazed member of the crew, who was outside the aircraft, could give no information concerning the rest of the crew.

Sgt. Francis looked in the door and the rear gun turret for possible survivors, afterwards climbing over the port mainplane on to the nose of the aircraft. Flames were entering the cockpit, and he seized a fire extinguisher, but could not put out the fire. He then jumped into the wrecked nose of the aircraft, where he found an airman on the floor, apparently dead, and the pilot unconscious in his seat with his feet trapped.

Sgt. Francis managed to extricate the pilot, and lifted him out to others who had now arrived on the scene. The first airman then seemed to show signs of life, and was dragged to a position where others could pull him from the aircraft with a salvage hook. Sgt. Francis then satisfied himself that no other person was in the wreckage before returning to a safe distance. In spite of an injured hand, he continued to assist in salvage operations for some time. He displayed courage and resource of a high order throughout.

Cpl. William John BALLS.—In May, 1941, this airman was a member of a party completing the loading of a tender with parts from a disabled aircraft at a Royal Air Force station, when a parachute flare exploded inside the tender and burst into flames. Although fully aware that the lorry contained ammunition in addition to valuable equipment, Cpl. Balls, in spite of the blaze and fumes from extinguishers which were being used, sprang into the lorry and commenced to throw out drums of ammunition.

When forced back by fumes he jumped out of the tender and put on his gas mask, and then succeeded in removing the ammunition from the tender. By his courageous act, this airman undoubtedly saved the vehicle and contents from becoming a total loss, and it may well be that his promptitude prevented residents in houses in the immediate vicinity of the aerodrome from becoming casualties.

A/C.1 David Idris HOWELLS.—One night in May, 1941, an aircraft, in which were an instructor and pupil, turned over on the flare path and burst into flames. A/C. Howells, who was on duty with the fire piquet, with complete disregard for his own safety, immediately dashed into the flames and succeeded in extricating both the occupants of the aircraft. In doing so, A/C. Howells received severe burns to his hands. Nevertheless, by his promptness and gallant devotion to duty he saved the lives of both the instructor and his pupil.

COOL HEADED: The solar topee and uniform which have been designed for personnel of the W.A.A.F. posted to the Middle East.

ANGLO-AMERICAN FIGHTERS: Three Curtiss Tomahawks in Vic formation. A large number of these valuable aircraft are now in service with the R.A.F., particularly in the Middle East.

Badges for Dominion W.A.A.F.

WOMEN from the Dominions who are serving in the W.A.A.F. are now entitled to wear the name of their Dominion as an arm badge, following the practice of Dominion personnel in the R.A.F. For wear with home pattern service dress the letters are embroidered or woven in light blue and for tropical uniforms in red on khaki cloth. Birth in the Dominion concerned or residence there for a certain number of years entitles a member of the W.A.A.F. to bear its name.

Arm badges have hitherto been worn by men from Rhodesia, Canada, Australia, New Zealand and South Africa. A "Newfoundland" badge may now be worn by men or women born in Newfoundland or resident there for five years before enrolment.

Roll of Honour

Air Ministry Casualty Communique No. 80.

THE Air Ministry regrets to announce the following casualties on various dates. The next-of-kin have been informed.

Royal Air Force

KILLED IN ACTION (WHILE FLYING IN OPERATIONS AGAINST THE ENEMY.—Sgt. G. S. Bradbury; Sgt. A. S. Cassells; Sgt. E. A. Davies; Sgt. D. H. Howe; Sgt. R. S. Mutimer; Sgt. C. W. H. Smith; P/O. W. E. A. Wand; Act. Flt. Lt. P. R. Wylde; Flt. Sgt. S. D. Yeomans, D.F.M.

PREVIOUSLY REPORTED MISSING BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—Sgt. J. Chester; Sgt. A. A. Cross; Sgt. F. Hughes; P/O. H. S. Sadler; Cpl. D. Stott.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Sgt. J. H. Angus; Sgt. G. W. F. Ashwin; Sgt. R. Cherrington; Sgt. I. R. W. Clark; P/O. J. A. Duff; P/O. R. G. Goode; P/O. R. G. Lewis; P/O. C. P. Morris; Sgt. D. C. Murrell; Sgt. S. Newman; Sgt. A. K. Perkins; Sgt. A. A. Rogers; Sgt. W. O. Shortland; F/O. G. M. Simpson; Sgt. J. Sugden; P/O. E. A. Tingey; Sgt. C. F. Young.

PREVIOUSLY REPORTED MISSING BELIEVED KILLED IN ACTION, NOW REPORTED KILLED IN ACTION.—Flt. Sgt. G. W. Knight.

PREVIOUSLY REPORTED MISSING, NOW REPORTED KILLED IN ACTION.—P/O. J. S. Logan.

WOUNDED OR INJURED IN ACTION.—Sgt. A. Denovan; Sgt. L. W. Duchemin; Sgt. J. T. Edwards; Sgt. D. L. Ferraby; Act. Sqn. Ldr. G. K. Gilroy, D.F.C.; P/O. G. S. E. Morris; P/O. V. D. Page; Sgt. J. A. Purves; P/O. J. R. Stoop; Sgt. C. J. Stuart; Sgt. W. H. Walker.

PREVIOUSLY REPORTED WOUNDED OR INJURED ON ACTIVE SERVICE, NOW REPORTED WOUNDED OR INJURED IN ACTION.—Sgt. C. W. Wilson.

DIED OF WOUNDS OR INJURIES RECEIVED IN ACTION.—Sgt. C. Clark; Sgt. D. H. Conibear; Sgt. G. E. F. Godley.

MISSING BELIEVED KILLED IN ACTION.—Flt. Sgt. G. H. Appleyard; Sgt. K. V. Attew; P/O. A. F. Buck; P/O. D. L. Cropper; Sgt. T. G. Davies, D.F.M.; Sgt. D. C. K. Dunne; Flt. Sgt. R. W. J. Green, D.F.M.; Sgt. J. Guest; Sgt. G. Haines; Sgt. D. A. D. Hoare; Flt. Sgt. C. H. Horner; Act. Wing Cdr. R. G. Hurst; Sgt. F. L. T. Ireson; Sgt. H. Jackson; P/O. J. C. Jenkins; P/O. E. J. Lamb; Act. Flt. Lt. A. E. Lewin; Sgt. K. J. Lord; Sgt. W. F. McKay; Flt. Lt. J. P. Magrath; Sgt. E. Marsden; F/O. J. P. Middleburst; Sgt. T. Morris; P/O. V. W. Olson; Sgt. D. F. J. Phillips; Sgt. C. E. Powell; Sgt. C. L. Ray; Sgt. J. Rooney; Flt. Lt. J. F. Sharp; P/O. J. G. Shepherd; P/O. P. Singleton; P/O. H. Sorenson; P/O. P. H. Standfast; Flt. Sgt. T. E. Stepney; Sgt. J. P. Sullivan; Sgt. J. N. B. Tate; P/O. E. B. Topp; Sgt. P. J. Vickery; P/O. E. D. Vivian; Sgt. G. D. White; Sgt. D. A. Wilson; Sgt. L. H. Wood.

MISSING.—Sgt. J. N. Alder; Sgt. F. W. Alleway; Sgt. E. R. Amos; Sgt. J. A. Anderson; Sgt. E. Ashworth; Sgt. E. Bainsbridge; Sgt. V. E. Baker; Flt. Lt. K. R. Ball; Sgt. A. L. D. Barrie; Flt. Lt. W. B. Baxter; Sgt. E. Bayley; Sgt. A. Beacham; Flt. Sgt. T. Beattie, D.F.M.; Flt. Sgt. R. R. Bell; Flt. Sgt. G. R. Birt, D.F.M.; P/O. W. R. Bleyce; Sgt. T. M. Blundell; P/O. D. M. Bolton; Sgt. J. H. Bolton, A/C.1 F. J. Boswell; Sgt. J. W. Bottomley; Cpl. C. D. Bradbury; Sgt. J. A. Brown; P/O. P. Brown; P/O. A. F. Bruce; Sgt. L. R. Burrows; Act. Wing Cdr. K. O. Burt, D.F.C.; Sgt. R. L. Burton; P/O. J. L. Calvert; Sgt. W. S. Campbell; Sgt. N. S. Cardell; Sgt. C. H. Chandler; Act. Flt. Lt. C. C. Cheshire; P/O. H. M. Clark; Sgt. R. T. Clark; L.A/C. J. W. Clarkson; P/O. P. K. Clench; Sgt. H. O. Cook; L.A/C. G. E. Cooper; P/O. R. Cox; Sgt. T. Craven; Sgt. D. W. E. Creedy; Sgt. B. Crocker; Sgt. L. C. Crook; Act. Flt. Lt. D. Crowley-Milling, D.F.C.; Sgt. E. Cullen; Sgt. W. J. Culley; Sgt. A. D. W. Curr, D.F.M.; Sgt. J. H. H. Cutmore; Sgt. P. E. H. Dangerfield; Sgt. M. K. Daniels; Sgt. A. Davies; Sgt. K. A. Dean; Sgt. C. Deges; P/O. E. E. Dennis; Sgt. D. G. Dennis-Smither; Sgt. W. H. Dickens; F/O. S. H. Dowse; P/O. R. M. East; Sgt. N. V. Edwards; Sgt. W. T. Ellis; Sgt. D. M. Evans; L.A/C. D. C. F. Evans; P/O. J. E. Evans; A/C.2 D. Faram; P/O. P. Farrugut; Sgt. P. L. Ferebee; Flt. Sgt. I. N. Forsyth; Sgt. D. G. Fothergill; Sgt. F. D. Fowler; Act. Cpl. A. Freeborn; A/C.2 A. Fullerton; Sgt. R. A. Galbraith; Wing Cdr. P. A. Gilchrist, D.F.C.; Sgt. T. E. Gledhill; P/O. K. F. Glenn; Sgt. A. Glover; P/O. J. D. Gould; Sgt. S. E. Gould; Sgt. D. M. Greedy; F/O. C. A. S. Greenhill, D.F.C.; Sgt. R. C. G. Griffin; Sgt. L. B. Gruer; Sgt. E. C. Gurmin; Sgt. R. Haley; Sgt. E. W. Hall; Sgt. P. A. Hammond; Sgt. C. W. Hancock; Sgt. M. C. Harvey; Cpl. E. J. Hedley-Smith; L.A/C. A. H. Hendrie; Sgt. S. O. Hinkfield; L.A/C. S. Hooper; Sgt. P. H. T. Horror; Sgt. R. Horsburgh; Sgt. G. P. Imison; A/C.2 E. R. Jack; P/O. R. S. Jameson; P/O. A. O. Johnson; Sgt. J. G. Jones; Cpl. R. T. Jones; P/O. A. W. Lambert; P/O. C. Landreth; Sgt. J. T. Leitch; Act. Flt. Lt. G. I. Lewis; Sgt. J. R. Littlefield; P/O. M. Littlewood; Sgt. R. Lloyd-Jones; Sgt. G. S. Lodington; Sgt. T. J. McHugh; Sgt. J. M. Macilwraith; P/O. K. J. McKelvie; Sgt. H. B. McKenzie; Sgt. D. H. McPhail; Sgt. R. G. MacRobert; Flt. Sgt. G. D. Mansel; A/C.1 A. Martin; L.A/C. N. R. Martin; Sgt. J. I. Mell; Sgt. W. N. K. Mellon; A/C.2 G. W. Michaelson; Sgt. N. Moores; Sqn. Ldr. B. G. Morris; Sgt. S. Morris; Sgt. D. Morrison; A/C.1 L. B. Mortimer; Sgt. J. Moules; Sgt.

A. T. Niven; Sgt. W. R. Norman; P/O. J. J. Nottidge; Sgt. A. G. Oliver; Flt. Sgt. D. Palmer; P/O. L. W. Parfitt; A/C.1 F. H. Parker; Sgt. P. C. Pocock; Sgt. T. Porteous; Sgt. E. F. Porter; Sgt. G. M. Porter; P/O. J. Prescott; Flt. Sgt. A. P. Price, D.F.M.; Sgt. I. Price; Act. Flt. Lt. S. Proud; Sgt. D. T. Ratcliffe; Sgt. J. M. Reed; Flt. Sgt. E. F. Reeve; Sgt. G. O. Reynish; Sgt. A. H. Rhodes; Sgt. C. Rhodes; Sgt. B. A. J. Richardson; Cpl. H. V. Richmond; Sgt. E. N. R. Robertson; Sgt. W. S. Robinson; P/O. B. B. H. Rodwell; A/C.2 R. D. Rogers; P/O. G. C. Rolland; P/O. A. C. Rossiter; Sgt. V. Scholey; Sgt. S. R. B. Severn; Sgt. E. Shoosmith; P/O. G. A. Skelly; Sgt. G. J. Smalley; Sgt. H. Smith; Sgt. G. C. Starkey; Act. Flt. Lt. J. Stokes; Sgt. J. H. Storey; Sgt. A. T. Taylor; Act. Sqn. Ldr. G. R. Taylor, D.F.C.; A/C.2 D. C. Theobalds; L.A/C. F. V. Thom; A/C.2 I. G. Thomas; Sgt. R. M. Thomas; Sgt. E. C. Thompson; Sgt. R. A. R. Thompson; L.A/C. F. W. Thorpe; P/O. M. W. Tilley; P/O. J. A. Timmis; Sgt. R. T. Timms; Sgt. A. E. Varnsverry; Sgt. R. L. Viner; Act. Sqn. Ldr. M. W. Waddington; P/O. L. Ward; Sgt. R. C. Wash; Cpl. J. Welsh; Sgt. R. H. Westbury; Flt. Sgt. W. Wetherill; F/O. R. G. M. Wigham; Sgt. P. E. Whiting; Sgt. O. L. M. Williams; Act. Flt. Lt. A. L. Winskill; Sgt. S. Wintersgill; Sgt. F. Wood; Sgt. J. C. Woods; Flt. Sgt. W. Woods; Sgt. C. F. Young; Act. Flt. Lt. H. S. Young; Sgt. M. A. Young.

MISSING, BELIEVED KILLED ON ACTIVE SERVICE (WHILE ENGAGED ON NON-OPERATIONAL FLYING DUTIES OR ON THE GROUND THROUGH ENEMY ACTION).—Sgt. W. C. Dear; Sgt. S. C. Driver; A/C.1 W. T. Guilfoyle; L.A/C. A. E. Lee; L.A/C. W. L. Morris; Sgt. F. A. Tysall.

KILLED ON ACTIVE SERVICE.—Flt. Sgt. F. A. Allcroft; P/O. R. Anne; L.A/C. A. Bell; P/O. L. R. Blackwell; Sgt. J. W. R. Boggis; P/O. R. O. Boon; P/O. D. G. L. Buckley; Sgt. F. N. Cave; Sgt. C. Cawthorne; P/O. P. C. Chappell; Sgt. G. E. Chugg; Sgt. N. D. Cryer; P/O. J. M. E. Daniels; P/O. E. A. Dare; L.A/C. V. L. Deroo; F/O. P. B. Doorly; P/O. J. R. Duncan; P/O. J. H. Eastwood; A/C.2 J. Edgecombe; Sgt. W. Fell; L.A/C. J. H. Foote; Sgt. J. A. Gibbs; P/O. A. G. Gill; Sgt. F. Gilliatt; Sgt. A. J. Grenyer; P/O. H. W. Griffin; Sgt. A. Handley; Sgt. L. W. Harris; Sgt. G. W. Hemsley; Sgt. S. J. Hobbs; F/O. H. B. L. Hough; Sgt. A. J. Howes; Sgt. T. N. Hudgell; P/O. K. Lancaster; P/O. S. H. Last; Sgt. Lenfesty; L.A/C. A. Mackay; Flt. Sgt. M. F. Mills; P/O. D. C. Moore; Sgt. J. M. O'Grady; Sgt. H. B. Olson; Sgt. W. H. Petratos; A.Apce. W. G. Powell; P/O. A. R. Preston; L.A/C. G. E. Pyper; Sgt. G. M. Scott; Sgt. J. P. Shaw; Sgt. R. J. Smith; Sgt. A. W. Stanley. P/O. G. M. Stocker; Act. Grp. Capt. J. E. Tennant, D.S.O., M.C.; Sgt. J. Tinker; Sgt. J. T. Travis; Sgt. H. E. Waite; Sgt. L. A. Webster; Sgt. D. H. Wesley, Sgt. F. G. Westoby, P/O. J. Young.

PREVIOUSLY REPORTED MISSING BELIEVED KILLED ON ACTIVE SERVICE, NOW PRESUMED KILLED ON ACTIVE SERVICE.—Sgt. W. H. H. Johnson; Sgt. C. E. Richardson; Sgt. P. Rutherford; A/C.1 N. Spriggs.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED ON ACTIVE SERVICE.—Wing Cdr. D. P. Lascelles; Flt. Lt. J. E. Pebody, A.F.C.; Flt. Sgt. W. D. Sherriff.

PREVIOUSLY REPORTED MISSING BELIEVED KILLED ON ACTIVE SERVICE, NOW REPORTED KILLED ON ACTIVE SERVICE.—L.A/C. W. Weatherburn.

WOUNDED OR INJURED ON ACTIVE SERVICE.—P/O. C. R. W. Armes; L.A/C. G. A. Butt; Sgt. J. Chivers; Sgt. F. V. Clarke; Sgt. W. Degg; P/O. C. W. Duffie; L.A/C. A. H. Hill; Sgt. S. F. McDonnell; Sgt. G. T. Relph; A/C.1 W. H. Tarling; L.A/C. R. C. Tench; A/C.1 L. J. Timmins.

DIED OF WOUNDS OR INJURIES RECEIVED ON ACTIVE SERVICE.—P/O. E. R. Davis; P/O. J. H. Emmerson; Sgt. D. C. Fowler; A/C.1 R. L. Robertson; P/O. N. J. Sharpe.

MICHAEL : A cocker spaniel owned by Sqn. Ldr. H. Budden, D.S.O., D.F.C., who has accompanied his master on many operational trips.

DIED ON ACTIVE SERVICE.—L.A/C. J. E. Armishaw; Sgt. L. E. Ayers; L.A/C. H. Birch; A/C.1 J. D. Boxhall; Cpl. P. G. Bradley; A/C.2 P. B. Bray; A/C.2 E. Cox; Flt. Lt. W. MacP. Cross; A/C.2 G. Davies; A/C.1 C. Day; A/C.2 B. H. S. Dickers; Act. Flt. Lt. C. Ewens; L.A/C. H. D. Hamilton; L.A/C. W. Hampton; A/C.2 F. S. Herbert; L.A/C. M. J. Hewitt; A/C.1 J. Highcock; L.A/C. G. Howsam; A/C.2 A. E. Hutchinson; L.A/C. D. G. Lee; Sgt. R. J. McGregor; A/C.1 A. Mundie; A/C.1 N. Paischowitz; A/C.1 E. N. Richardson; A/C.2 W. Scotney; L.A/C. R. W. Shearer; A/C.2 P. H. Sheppard; A/C.1 A. Spence; A/C.1 B. Tinsley; A/C.2 K. Treverton; A/C.2 F. S. Webster; A/C.1 J. Wells; A/C.2 R. G. Whitehead; L.A/C. A. Whittaker; A/C.1 A. Young.

PREVIOUSLY REPORTED MISSING, NOW REPORTED SAFE.—Sgt. A. B. Gibbs; A/C.1 W. H. Hudson; P/O. T. F. Kennan; Sgt. G. H. Livingstone; Sgt. F. B. Rowley.

PREVIOUSLY REPORTED MISSING BELIEVED KILLED IN ACTION, NOW REPORTED PRISONER OF WAR.—Sgt. E. W. Perkins.

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Flt. Lt. F. H. Babcock; Flt. Lt. G. D. Ball, D.F.C.; Sgt. G. McD. Barclay; P/O. G. H. Batchelor; Sgt. J. W. Davidson; Sgt P. L. Felton; P/O. W. M. W. Fowler; P/O. A. J. C. Hamilton; Act. Flt. Lt. J. Harrison-Broadley; Sgt. W. J. Jackman; Sgt. H. H. Joslin; P/O. G. F. Lowes; F/O. W. N. Menteith; P/O. R. W. B. Rainford; A/C.1 T. G. Skipworth; Sgt. S. C. Thompson; A/C.2 G. W. Trollope; L.A/C. E. A. Winterflood.

PREVIOUSLY REPORTED MISSING BELIEVED KILLED ON ACTIVE SERVICE, NOW REPORTED PRISONER OF WAR.—A/C.1 A. B. Elder; Cpl. R. W. Strong.

SERVICE AVIATION

AMENDMENT TO PRESS COMMUNIQUE NO. 78 UNDER THE HEADING KILLED ON ACTIVE SERVICE.—*For* Sgt. S. H. V. Durrell *read* Sgt. S. H. V. Durell.

Women's Auxiliary Air Force

DIED ON ACTIVE SERVICE.—A./CW.1 P. E. Thorogood.

Royal Australian Air Force

WOUNDED OR INJURED IN ACTION.—Sgt. W. N. Williams.

MISSING BELIEVED KILLED IN ACTION.—P/O. J. F. S. Kent.

MISSING.—P/O. W. G. Dalco; P/O. W. D. Ercleton; Sgt. C. J. Fuller; Sgt. D. R. Gale; Sgt. W. H. J. Gourley; P/O. K. M. Hicks; P/O. J. R. Horn; P/O. D. A. R. Munro.

KILLED ON ACTIVE SERVICE.—Sgt. M. C. Crombie; Sgt. G. J. Gould; Sgt. A. T. L. Mortimer; L.A/C. F. C. Wright.

DIED OF WOUNDS OR INJURIES RECEIVED ON ACTIVE SERVICE.—Act. Cpl. R. S. Burdus.

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Sgt. A. McB. Kerr.

Royal Canadian Air Force

KILLED IN ACTION.—Sgt. W. J. McQuade.

WOUNDED OR INJURED IN ACTION.—Sgt. G. J. Masse; Sgt. W. R. A. Pullen.

MISSING, BELIEVED KILLED IN ACTION.—Sgt. H. Ingleby.

MISSING.—P/O. K. H. Anthony; P/O. F. H. Beemer; Sgt. E. J. Conry; Sgt. N. H. J. Dalphond; Sgt. A. D. Day; Sgt. M. B. C. Delaney; Sgt. H. Hale; Sgt. L. W. J. Hart; Sgt. A. T. Hatton; P/O. A. O. Learmonth; Sgt. T. E. McGeragle; P/O. W. M. Mackay; Sgt. G. R. Menish; Sgt. J. S. Paton; Sgt. J. G. A. Richards; P/O. F. W. J. Scott; Sgt. J. P. Taylor.

KILLED ON ACTIVE SERVICE.—P/O. A. J. Y. F. Boulanger; Sgt. N. H. Burnett; Sgt. P. F. Chapman; Sgt. M. Fieldhouse; Sgt. L. Goldberg; Sgt. J. Gordon; P/O. V. J. Hall; Sgt. J. B. Kamedish; P/O. P. L. Nash; Sgt. C. Pullan; Sgt. W. T. Purdy; Sgt. A. A. Rodgers; Sgt. W. E. Snell; P/O. J. K. D. Williams.

WOUNDED OR INJURED ON ACTIVE SERVICE.—Sgt. L. G. Cornish; Sgt. N. D. Downie; Sgt. E. A. McD. Grange.

Royal New Zealand Air Force

KILLED IN ACTION.—P/O. R. P. Bell.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Sgt. F. J. Newman; Sgt. J. L. Owen; Sgt. R. W. Prout.

PREVIOUSLY REPORTED MISSING, NOW REPORTED KILLED IN ACTION.—P/O. W. J. Finlayson.

MISSING, BELIEVED KILLED IN ACTION.—Sgt. H. D. P. Dyer; P/O. J. E. McK. Steeds.

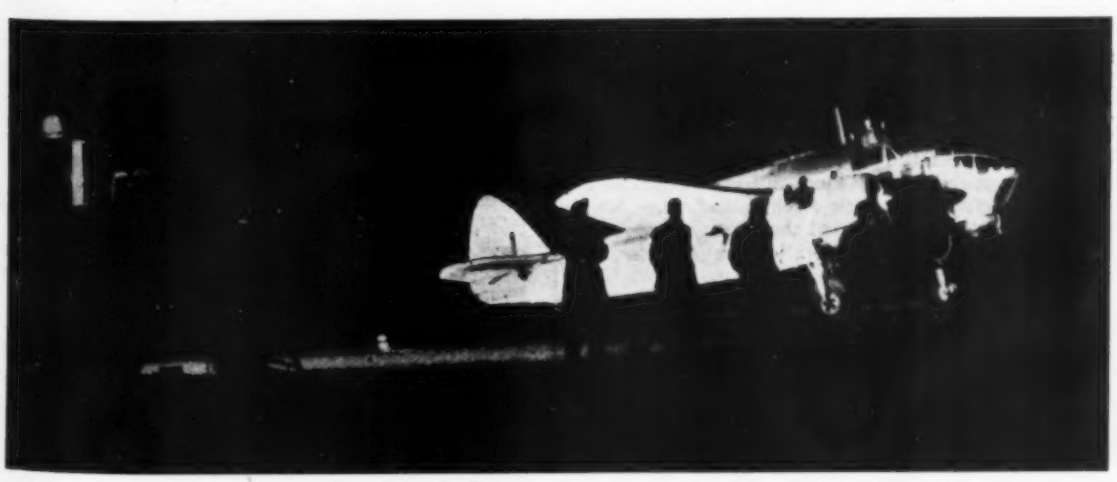
MISSING.—P/O. A. C. Anderson; Sgt. A. R. Harris; Sgt. C. H. Howard; Sgt. W. L. Knowles.

WOUNDED OR INJURED ON ACTIVE SERVICE.—P/O. S. R. O. Richmond.

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Sgt. R. J. A. Backstock.

South African Air Force

MISSING.—Lt. D. L. Buchanan; Lt. C. O. Clarkson; Sgt. G. C. Green; Sgt. D. G. Malan; Sgt. H. A. Read; Lt. A. S. Russel; Sgt. Saks; Sgt. H. H. Thomas.



LIGHT AND SHADOW : A Beaufort about to take off for a night operational flight.

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